on the diffusivity of ethylene in the particular helium-oxygen mixture which is applied. Similarly, when the atmospheric pressure is reduced the diffusivity of ethylene per unit volume of air is increased; this does not change the rate at which the fruit produces ethylene, but the partial pressure of ethylene in the intercellular spaces declines to the extent that the atmospheric pressure is lowered. Since the rate of escape of ethylene from the fruit is dependent upon the diffusivity of ethylene in the ambient gas phase, it follows that ethylene moves through the tissue and escapes from it in a gas phase.
30. R. E. Young, J. Romani, J. B. Biale, *Plant Physiol.* **37**, 416 (1926).
31. M. Lieberman, S. Asen, L. W. Mapson, *Nature* **204**, 756 (1964).
32. S. P. Burg and E. A. Burg, *Botan. Gaz.*, in press.
33. Kidd and West (*34*) concluded that "throughout its growth the apple produces ethylene in very small quantities, but a minimum or threshold concentration in the tissue is necessary before respiratory activity is affected." They speculated that ripening might be induced by "a change with age in the threshold for ethylene stimulation"; also see E. Hansen, *Proc. Amer. Soc. Hort. Sci.* **43**, 69 (1943).
34. F. Kidd and C. West, *Plant Physiol.* **20**, 467 (1945).
35. S. P. Burg, in *Régulateurs Naturels de la Croissance Végétale*, Intern. Colloq., Gif, France, 1963 (Centre National de la Recherche Scientifique, Paris, 1964), p. 719.
36. R. Gane, *Nature* **134**, 1008 (1934).
37. S. P. Burg and K. V. Thimann, *Proc. Natl. Acad. Sci. U.S.* **45**, 335 (1959).
38. J. S. Friedenwald and G. D. Maengwyn-Davies, in *A Symposium on the Mechanism of Enzyme Action*, W. D. McElroy and B. Glass, Eds. (Johns Hopkins Univ. Press, Baltimore, 1954), p. 154.
39. S. P. Burg and K. V. Thimann, *Plant Physiol.* **35**, 24 (1960).
40. D. F. Meigh, K. H. Norris, C. C. Craft, M. Lieberman, *Nature* **186**, 902 (1960).
41. C. W. Fischer, *N.Y. State Flower Growers' Bull.* **49**, 9 (1949); **61**, 1 (1950); C. E. Williamson, *Phytopathology* **40**, 205 (1950); W. H. Smith, D. F. Meigh, J. C. Parker, *Nature* **204**, 92 (1964).
42. P. W. Zimmerman and F. Wilcoxon, *Contrib. Boyce Thompson Inst.* **7**, 209 (1935); E. Hansen, *Plant Physiol.* **21**, 588 (1946); P. W. Morgan and W. C. Hall, *Physiol. Plantarum* **15**, 420 (1962); F. B. Abeles and B. Rubenstein, *Plant Physiol.* **39**, 963 (1964).
43. M. Lieberman and C. C. Craft [*Nature* **189**, 243 (1961)] reported that subcellular particles from apples and tomatoes produce ethylene if they are prepared at an acid *p*H and fortified with certain thiol-containing compounds. Subsequently the gas was identified as ethane (*44*, *45*), and its production was shown to be dependent on the presence of linolenic acid [M. Lieberman and L. W. Mapson, *Nature* **195**, 1016 (1962)] and demonstrable in a nonenzymatic system containing iron (*41*). Recently M. Lieberman and L. W. Mapson [*Nature* **204**, 343 (1964)] have described a nonenzymatic system which produced predominantly ethylene in the presence of copper, ascorbic acid, and "aged" linolenic acid, and they report that cytoplasmic particles from apples evolve ethylene in the presence of copper and ascorbic acid.
44. S. P. Burg and E. A. Burg, *Nature* **191**, 967 (1961).
45. D. F. Meigh, *ibid.* **196**, 345 (1962).
46. M. S. Spencer [*Nature* **184**, 243 (1959)] reported that subcellular particles derived from tomatoes produce ethylene, but others (*44*, *45*) were unable to duplicate these results. G. R. Chandra, M. Spencer, and M. Meheriuk then pointed out [*Nature* **194**, 361 (1962)] that the production only occurs after the particles are "aged" or treated with high-frequency sound, but D. F. Meigh (*45*) noted that ethylene is formed when a nonenzymatic mixture containing sucrose and adenosine triphosphate is sonically treated. Spencer's subcellular system may be similar to that of Lieberman and Mapson (*43*), for the former must be aged before ethylene is produced, whereas in the latter case linolenic acid must be aged to be "activated." Subsequently, R. Chandra and M. Spencer have claimed [*Nature* **197**, 366 (1963)] that by their methods it is possible to prepare ethylene-producing subcellular particles from rat liver, rat intestinal mucosa, and the mold *Penicillium digitatum*.
47. S. P. Burg and K. V. Thimann, *Arch. Biochem. Biophys.* **95**, 450 (1961); S. P. Burg and E. A. Burg, *Nature* **203**, 869 (1964).
48. C. H. Wang, A. Persyn, J. Krackov, *Nature* **195**, 1306 (1962).
49. D. J. Reed and C. H. Wang, *Can. J. Microbiol.* **5**, 59 (1959).
50. M. A. Muhs and F. T. Weiss, *J. Amer. Chem. Soc.* **84**, 4697 (1962).
51. W. C. Hall and P. W. Morgan, in *Régulateurs Naturels de la Croissance Végétale*, Intern. Colloq., Gif, France, 1963 (Centre National de la Recherche Scientifique, Paris, 1964), p. 727.
52. For example, during ethylene action in pea-stem sections the uptake and destruction of C^{14}-indole-3-acetic acid (the native auxin) is not altered, and its transport from the apex to the base of the section proceeds at a normal rate (also see *6* and *7*). Although it seems likely (see, for example, *6*, *7*, *13*) that production of auxin is reduced when ethylene is present, this reduction cannot be a requisite for ethylene action because the gas is equally effective in the pea-stem assay (where the site of auxin production has been removed) in the presence of widely differing concentrations of applied indole-3-acetic acid. Ethylene does not duplicate the effect of auxin in enhancing the growth of the tissue and does not prevent auxin from stimulating growth (measured as water uptake).
53. The data in this table have been compiled from the reports cited in *2*, *15*, *20*, *26*, *27*, *32*, *54*, and from R. Gane, *Gt. Brit. Dept. Sci. and Ind. Res. Rept. Food Invest. Bd.* **1935**, 123 (1936); J. M. Lyons and H. K. Pratt, *Proc. Amer. Soc. Hort. Sci.*, in press; J. B. Neiderl, M. W. Brenner, J. N. Kelley, *Amer. J. Botany* **25**, 357 (1938); United Fruit Co., unpublished data; S. P. Burg and E. A. Burg, unpublished data.
54. S, P. Burg and E. A. Burg, *Nature* **194**, 398 (1962).
55. Ethane, *trans*-2-butene, *cis*-2-butene, isobutene, and nitrous oxide were inactive at the highest concentration which could be tested (300,000 ppm), and acetonitrile at $10^{-1}M$. The following were inactive at all concentrations below the toxic level which is indicated in parentheses: dichloromethane, *cis*-dichloroethylene, *trans*-dichloroethylene, trichloroethylene, tetrachloroethylene, hydrogen sulfide, ethylene oxide, allyl chloride (all approximately 10,000 ppm); carbon dioxide (100,000 ppm); hydrocyanic acid ($3 \times 10^{-5}M$); acrylonitrile ($1.7 \times 10^{-4}M$); hydrogen peroxide ($10^{-2}M$); potassium azide ($4 \times 10^{-3}M$); allyl alcohol ($10^{-3}M$); and formaldehyde ($10^{-4}M$).
56. The studies cited in references *15*, *32*, *51*, *35*, *44*, and *47* were supported by Public Health Research Grant EF-00214 from the Division of Environmental Engineering and Food Protection, and this review was written while S.P.B. was the recipient of Research Career Development Award 1K3GM6871 from the PHS.

Women in Science: Why So Few?

Social and psychological influences restrict women's choice and pursuit of careers in science.

Alice S. Rossi

Where women are concerned, the late 1940's and the 1950's were marked by a national mood of domesticity demonstrated by the rapid rise in the birth rate and the flight of families to the suburbs. It was a period of high praise for woman's domestic role. That mood has shifted in the 1960's. Educators, employers, government officials, and manpower specialists are urging women to enter more fully into the occupational life of the nation. A President's Commission on the Status of Women has recently issued a set of wide-ranging recommendations to this end (*1*). Particular stress has been put on the need for women in fields in which there is a critical shortage of manpower—teaching, science, and engineering—and conferences on women in science have been held under federal auspices, at Marymount College in 1963 and at the Massachusetts Institute of Technology in 1964.

What can we expect as a result of this campaign? Working women in the industrial, service, and clerical occupations will probably experience an improvement in status. The implementation of the Equal Pay Act and the retraining possible under the Manpower Development and Training Act will be of help to such women, as will all attempts to improve community child-

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care and housekeeping facilities, increased tax deductions for families including a working mother, and the like. A steady supply of older, married women secretaries, clerks, machine tenders, and technicians seems assured.

A second group directly benefiting from the campaign consists of women residents of the national and state capitals. There is a renewal of optimism among women in government employment, and some indications that in Washington itself their opportunities for advancement may be increasing. But a very large proportion of women in all grades of the Civil Service are unmarried, and a very large proportion of those who are married have no children (*2*).

Most college-educated women in this country are married and living with their husbands and children. Whether we are interested in the status of women or in the needs of science or both, I do not think we can expect any appreciable increase in the representation of women in the top professions unless that fact is taken into account. As long as it is mostly spinsters or widows who are appointed or elected or promoted to a college presidency, a national commission, a senatorship, or a high post in a government agency or scientific institute, we cannot consider that a solution has been found to the problem of women's status in American society. Marriage, parenthood, and meaningful work are major experiences in the adventure of live. No society can consider that the disadvantages of women have been overcome so long as the pursuit of a career exacts a personal deprivation of marriage and parenthood, or the pursuit of happiness in marriage and family life robs a woman of fulfillment in meaningful work.

The Present Situation

How many women are there in the fields of science and engineering in the United States, and what are their characteristics? The latest figures available are from the 1960 Census. In 1960 (*3*), only 9 percent of the employed natural scientists and less than 1 percent of the engineers were women (see Table 1). Within these broad fields, there was considerable variation: from 2 percent in the earth sciences and 4 percent in physics to 26 percent in mathematics and 27 percent in the biological sciences (*4*). Women lost rather than gained ground in the sciences between 1950 and 1960, for although they appeared in greater absolute numbers in 1960, the rate of increase was much lower than that of men. Thus while there was a 209 percent increase in the number of women mathematicians, the number of male mathematicians increased 428 percent, so that the proportion of women actually declined from 38 percent to 26 percent in that decade. Hiestand (5) has shown that this is a characteristic of all occupations undergoing an accelerated rate of growth. The majority group in the labor force is white men, and it is their growth pattern which defines the rapidly growing fields. Since women constitute a far smaller proportion of the total labor force, they can usually provide only a small proportion of the added manpower in rapidly growing fields. That this is not the whole story, however, is suggested by the fact that in fields like medicine and law, which have not had the same accelerated rates of growth, women were no better represented in 1960 than in 1950.

Table 1. Employment of women in sciences and engineering, 1950 and 1960, as percentage of total personnel, and rate of increase of each sex (*3*).

Occupation	Female (%)		Increase (%)	
	1950	1960	Female	Male
Biologists	28	27	38.2	56.2
Chemists	10	9	— 3.6	13.5
Geologists, geophysicists	6	2	—27.3	81.1
Mathematicians	38	26	209.8	428.1
Physicists	6	4	20.2	92.5
All natural scientists	11	9	10.4	30.0
All engineers	1.2	0.8	11.0	64.3

Women employed in the scientific and engineering fields in 1960 were less likely than men to have advanced degrees, particularly the Ph.D., less likely to be employed in industry, considerably less likely to be married; they earned less money and worked fewer hours per week. At each level of educational attainment the median salary of men was markedly higher than that of women. Half the women scientists but only one-fourth of the men worked in educational institutions, and men were four times as likely as women to be in industrial management (*6*). Among those who were teaching science, women were more likely than men to work less than 35 hours a week; significantly larger proportions of men reported work weeks in excess of 40 hours. As of 1960, the chances were rather slim that a woman in engineering or science would find part-time employment other than in teaching. For example, the proportion reporting fewer than 35 hours a week was 41 percent among women teaching chemistry above the secondary school level, but only 9 percent among women identifying themselves as "chemists" (*7*, table 4).

Four out of five men scientists but only two out of five women scientists were married and living with their spouses (*7*, table 3). Since these figures represent employed women only, they exaggerate the proportion of unmarried women among those trained as scientists. Significant numbers of women have been trained in the professions but withdraw for varying periods of time to home and child-rearing. Table 2 shows what proportions of experienced professional men and women in 1960 were in the labor reserve (defined as those not employed and not seeking employment but who worked in a given field within the previous 10 years) (*8*). Among men, there is little withdrawal from the active labor force before age 65; among young men the proportion is typically under 5 percent. Among women, sizable proportions withdraw, particularly in the 24 to 44 age group, when family responsibilities are at their peak.

There are considerable differences among the professions, however, in this regard. Women doctors have very low withdrawal rates, whereas the rates for women secondary school teachers and engineers are moderately high. It is rather surprising to find that women scientists have an even higher rate of voluntary withdrawal than the teachers—51 percent as against 34 percent. One might expect that having undertaken careers in science, still a pioneer field for women, these women would have motivation high enough to offset the easier accommodation of work and family responsibilities to school teaching. Apparently this is not so.

What about the future supply of women in science? An examination of the career plans of younger women,

in a study of college seniors of the class of 1961 by the National Opinion Research Center (*9*), indicates no new trend toward more women physicists and engineers, although there is an increase of women headed for the biological sciences. Among college seniors planning graduate work in physics 8 percent were female, in engineering 1 percent, in chemistry 20 percent, in mathematics 28 percent, in all biological sciences 43 percent. Furthermore, some of these women will become secondary school science teachers rather than practicing scientists. A follow-up study one year after graduation showed that among those actually enrolled in graduate school, the percent female in the physical sciences was 16, in the biological sciences 34 (*10*). If the pattern shown in Table 2 holds for this younger group of women, by 1965 about half of them will have voluntarily withdrawn at least temporarily from advanced training or jobs in science.

Several questions emerge from the foregoing review. Why are there so few women in science? Why are they less apt to get advanced degrees than men? Why are they less apt to marry? Why do they withdraw from their fields?

The Priority of Marriage

What a man "does" defines his status, but whom she marries defines a woman's. In meeting strangers, one can "place" a man socially by asking what he does, a woman by asking what her husband does. This is particularly true for the top professional and technical strata of American society. Only small proportions of the wives of doctors, scientists, engineers, and lawyers are employed, ranging (in 1960) from a low of 16 percent of doctors' wives to a high of 25 percent of scientists' wives (*7*, table 12). In contrast, 44 to 47 percent of the wives of librarians, social workers, and school teachers are employed.

This has decided implications for the paths young women see as open to them for success in American life. A man must express his intelligence and ambition in the occupational sphere. A woman's ambition can find an outlet in marriage or in work, seldom in both. If a woman has a successful husband, there are no cultural pressures upon her to use her intelligence or training in the work of the world. In fact her husband may resist a desire on her part for such a separate career, for a wife with leisure is one symbol of his success, and a wife's career might require him to carry some of the parental responsibilities his wife has carried for him.

I think it is the awareness that marriage and careers are not now compatible for women in the upper middle class (despite protestations to the contrary in recent years) that lies behind the often pathetic vacillations of high school and college girls between the pursuit of social popularity (a route to successful marriage) and excellence in scholarship (a route to successful careers). Surely it plays a role in the different concerns parents have for their adolescent boys and girls—the educational goals of their sons and the dating patterns of their daughters.

A sample of women college graduates 3 years beyond graduation were asked the following question (*11*): "An American woman can be very successful in a variety of ways. Which of the following would you most like to be yourself?" The most frequent answers were: to be the mother of several accomplished children and to be the wife of a prominent man. Yet some echoes of earlier aspirations and the imprint of their college education are found in their responses to the further question, "Which of the following do you personally admire very much?" Four out of five chose winners of scientific, scholarly, or artistic awards. They admire the minority within their sex who have careers, but choose themselves to live in the shadows of their husbands' and children's accomplishments.

Unless there are changes in the organization of professional and technical work or in the attitudes of men toward women's roles, it seems likely that fewer rather than more college-trained women will pursue serious careers in the future, for there has been a steady increase in the proportion of the male labor force found in the top occupations. This is not to say that wives of such men will not work. They will, particularly early in the marriage when their earnings supplement university stipends to support the graduate training of their husbands. And we shall hear from these women again when they reach their forties. As long as their husbands are not "too" successful, they may become social workers, teachers, computer programmers, professional or technical aides in laboratories or offices. Only rarely will they become doctors, lawyers, scientists, or engineers. Harriet Martineau's observation in 1834 that the "prosperity of America is a circumstance unfavorable to its women," meaning women are not "put to the proof as to what they are capable of thinking and doing" (*12*), is as true for the upper middle class in 1964 as it was when she compared America with England on her first visit to the young nation.

It is ironic that with a life span now long enough to experience many and varied adventures of the mind, the spirit, and the senses, the major life experiences of marriage and parenthood and the intellectual excitement of advanced study are compressed into the same narrow few years of early adulthood. Instead of savoring each to the full and in their turn, we feast upon all three simultaneously as on a triple-decker sandwich. This quickened pace of life and the earlier age at which marriage, parenthood, and occupational success take place play an important role in lowering the career aspirations of women and in deflecting them from the pursuit of such goals as they have. There is not enough time in late adolescence for young women to evolve a value system of their own and a sense of direction toward an individual goal, for they are committing themselves prematurely to marriage and adapting to the goals of their husbands at the expense of their own emotional and intellectual growth.

Men are more conservative than women concerning the role of careers in the lives of women. Much larger proportions of college-trained men than women in the NORC career development study (*11*) believed women should not choose a career difficult to combine with child-rearing, and disapproved of women's working when they have preschool children. The same men were between two and three times more likely than the women to say there was "no need at all" for the major recommendations made by the President's Commission on the Status of Women—increased child-care facilities, equal opportunity in hiring and promotion, and encouraging more women to enter the professions and national political office.

Women see the sharp differences between their own views and those of "most men." Women in the NORC sample were given a brief account of a hypothetical family conflict and asked how they themselves would resolve it

and how they thought "most wives" and "most husbands" would resolve it. In the story, a woman graduated from college with honors in biology, married, and held a teaching job while her husband completed law school. Now he has a degree and a good job. Both wish to have children, but she would like to take an advanced degree in biology and eventually pursue a career in biological research. The respondents were asked what decision the couple should make: to start a family and have the wife get the degree later; to start a family and give up the wife's career goal; to postpone child-bearing and let the wife get the degree now; or carry out both wishes simultaneously. Only one-fourth of the women thought the couple should start the family now, with the wife either giving up or postponing her training and career plans; but half of them believed these two decisions would be favored by "most wives," and three-fourths that it would be favored by "most husbands."

In actual fact, most women do as they say most husbands would prefer: they are less apt to complete any advanced training, highly likely to work after marriage and then withdraw for the child-bearing and -rearing years. The typical pattern of work for American women shows two peaks of employment, the first in their early twenties, the second in the 40 to 55 age group. As seen in Table 2, this withdrawal in the 24 to 44 age group is particularly high for women in the sciences. Thus in their expressed attitudes, women are less conservative than men, but their actual behavior reflects an adaptation to the views of men.

Table 2. Voluntary withdrawal from labor force* in selected professions, by age and sex (7); expressed in percentages.

Profession and sex	Age		
	25 to 44	45 to 64	65 or older
Natural scientists			
Women	51	13	61
Men	2	1	57
Engineers			
Women	31	13	42
Men	1	4	58
Secondary school teachers			
Women	34	13	65
Men	2	2	54
Physicians-surgeons			
Women	19	10	31
Men	2	2	25

* The labor force is defined as all persons, whether currently employed or not, who have worked in the stated capacity during the last 10 years. The figures are as of 1960.

Effect of Interruption of Career

During the last 5 years there has been a mushrooming of centers for counseling and retraining older women who wish to return to professional employment. I think there is a danger that by thus institutionalizing the withdrawal-and-return pattern of college-educated women, we may reduce even further the likelihood that women will enter the top professions. Older women who have not worked for many years may be retrained and contribute significantly to personnel shortages at the lower professional levels as laboratory assistants, technical writers, nurses, and school teachers, but only rarely as doctors, full-fledged scientists, and engineers. Not only is training for such fields a long and difficult process, but the pace of technological and scientific knowledge has been so rapid that even those who remain in these fields have difficulty keeping up, let alone those who return to advanced training after a 10-year break.

Even more fundamental, however, is the effect on potential creativity of withdrawal precisely during early adulthood. Lehman's researches into the relation between age and achievement (*13*) have shown that the quality of intellectual output is strongly related to age, and that in the sciences the peak of creative work is reached in the late twenties and early thirties. The small number of women included in his samples showed their most creative years to be no different from those of the men. They were making their major contributions during the very years when most American women withdraw and devote a decade or more to home and family.

If more women are to choose science and remain active in science, it must be possible for them to do so without lengthy interruption of their careers during their potentially most creative years. There has to be a better balance between marital, parental, and career obligations and pleasures for both sexes: work must be *less* dominant than it is in the lives of men in order for it to be *more* dominant in the lives of women.

New View of the Maternal Role

Women will not be strongly motivated to remain active professionally during the early years of child-rearing simply out of concern for the effect of withdrawal upon their intellectual creativity. The development of their children is a concern equal to if not greater than their own work. Until very recently, there was a widely held belief that any separation of the mother and the child would have dire consequences for the emotional development of the child, and many women who worked throughout their children's early years did so with considerable anxiety about the effect of their daily absence upon their children. It is only very recently that this myth has been laid to rest. A current volume of some 22 empirical studies on the employed mother (*14*) has shown that maternal employment has no unfavorable effects upon children. Of much greater importance than employment per se are the mother's reasons for working, the quality of the care the child receives in her absence, and the attitudes of her husband. In the last few years, social scientists have begun to stress the desirable rather than the unfavorable consequences of maternal employment (*15*, p. 615).

There is a second body of research on child development that reflects a further shift in the concept of the maternal role. For years psychologists focused rather exclusively on the mother's feelings toward and physical care and training of the child. Now there is increasing emphasis on the role of mothers in their children's cognitive development. It has been found that how well the child takes to his early school experiences is strongly related to whether he has had stimulating experience with language and ideas during his preschool years. The better educated the mother, the greater will this stimulation of the child tend to be. There is research currently under way testing the hypothesis that it is the lack of cognitive stimulation that contributes most heavily to poor school per-

formance among lower-working-class children (*16*).

The implications for social action in behalf of children in culturally deprived homes are clear: enrich the environment of the very young child by means of child-care facilities designed to provide such cognitive stimulation (*17*). The implications as regards children of college-educated parents are less clear-cut. Some child specialists may say that the mother is more necessary at home than ever, not only to love and care for the child but to stimulate the growing mind of the child. This is to stress the role of the mother as a *teacher*. She may be even more effective, however, as an *example* to the child. If she is utilizing her education in a professional job which keeps her alert and involved with things of the mind, she may transmit far more zest for learning than the educated mother who shelves her books along with her diploma. With the view that maternal employment will harm the child now shown to be unfounded, younger women are potentially free of one source of anxiety if they choose to pursue a profession.

Women and Science: Incompatible?

What is there about women on the one hand, and science on the other, that leads to such a very low affinity between them in American society? What are the major characteristics of the scientist, and why are women in our society less apt to have these characteristics than men?

The following thumbnail sketch of the scientist is based largely on the intensive research of Roe (*18*) on eminent physicists and biologists. Two caveats must be noted. First, there have been no detailed psychological studies of women scientists in any way comparable to those of men scientists. Some studies suggest that differences in students' interests and values are more closely related to their fields of study than to sex differences, but in drawing a portrait of the characteristics of the scientist it is an assumption rather than an empirically established fact that women scientists do not differ from men scientists in the major characteristics relevant to their occupational role. Secondly, Roe's studies of scientists were conducted in the 1940's with men largely in their fifties at that time. Whether younger men entering the considerably changed world of science in the 1960's and 1970's will differ we do not know, though a comparison of physics students with the physics faculty at a major university in the 1950's shows such striking similarity in personality and social traits as to suggest little change from generation to generation (*19*).

The four characteristics Roe found most typical of outstanding natural scientists are the following:

1) *High intellectual ability*, particularly spatial and mathematical.

2) *Persistence in work*; intense channeling of energy in work such that the greatest personal satisfaction was experienced when working.

3) *Extreme independence*, showing itself in childhood as a preference for a few close friends rather than extensive or organized social groups, and preference for working alone; in adulthood as a marked independence of intense relations with others and a preference for being free of all supervision.

4) *Apartness from others*; low interest in social activities, with neither preference for an active social life nor guilt concerning such tendencies toward social withdrawal.

All four characteristics manifest themselves early in life; hence a predisposition toward science as a career goal is established long before the college student makes a formal commitment to a "major." Furthermore, these are all characteristics girls in American society are considerably less apt to have than boys. Both at home and at school, girls are socialized in directions least likely to predispose them toward science as a career. What are these sex differences during the formative years?

Intellectual Ability

For many years it was assumed that there were practically no sex differences in intelligence, for studies relying on the Stanford-Binet intelligence test showed almost no differences between boys and girls. It had somehow been forgotten that, in standardizing this test, items which revealed consistent sex differences were discarded so that the scores of boys and girls could be evaluated against the same norms. During more recent years, as specific tests were constructed to measure different dimensions of intellectual and creative ability, consistent sex differences began to emerge.

These differences may be summarized as follows (*20*): Girls talk at younger ages, put words together into sentences somewhat sooner, and learn to read more easily than boys. After the fifth or sixth grade, however, boys do as well as girls in reading comprehension, though girls show somewhat greater verbal fluency. In mathematical skills there are no sex differences during the early school years, but during high school boys begin to excel, and by the time they take the Scholastic Aptitude Tests the boys score an average of 50 points higher on the mathematical portion, while girls score only 8 or 10 points higher on the verbal portion. Throughout school boys do better on spatial tests (for example, detecting a simple figure embedded in a more complex one), which suggests that "boys perceive more analytically, while the girls are more global, more influenced by all the elements of the field together" (*20*, p. 29).

Thus girls develop cognitive abilities along somewhat different lines than boys, and enter adolescence with a style of thinking less appropriate to scientific work. Any final interpretation of this sex difference awaits further research, but what is known to date is that one key lies in the kind and degree of training in independence the child receives. Bing (*21*) found that high verbal ability is fostered by a close relationship with a demanding and somewhat intrusive mother, while high mathematical abilities were enhanced by allowing a child a considerable degree of freedom to experiment on his own. Children whose scores on standard intelligence tests rise between their 6th and 10th years are highly likely to have been six-year-olds who were "competitive, self-assertive, independent and dominant in interaction with other children," while those who showed declining scores were "passive, shy and dependent" youngsters at six (*20*, p. 33).

Early Family Influences

If we look more closely at the family environment of the young child, we can guess at some of the sources of this difference in cognitive style between boys and girls. The scientist's characteristics of independence, persistence in work, and social isolation are mirrored in significant differences between the father and the mother as seen through the eyes of the child. No matter

what the father works at, the child sees him leave the family to pursue it; it is a normal part of every day's expectation that father will not be present. Mother, in contrast, is usually at home and instantly available, someone who takes care of the thousand details of home and family life, none of them so important that she cannot be easily interrupted. Even when he is at home, father may be far less "available" than mother.

It is easy for the child to conclude from daily observation that men work for long stretches of time at something important, and that men are less involved with people than women are. There is a consistency between these observations of the parents and the characteristics of young children. Very young girls have a greater interest in other people than boys have and are influenced to a greater extent by what other people think of them. Coleman (*22*) has found that in adolescence, girls are far more often involved in same-sex cliques than boys, who are more often independent loners. Girls comply with the demands of social situations more than boys do, whether at home in doing what parents ask of them or at school in doing what teachers ask. In short, by the example of their parents boys receive encouragement to stand on their own, to be alone, to aim high, and girls are encouraged to be cooperative and responsive to people and to minister to their needs.

The result of these early influences is a marked contrast between men and women in the values that underlie their career choices. Rosenberg (*23*) and more recently Davis (*24*) have indicated that the occupational value which most sharply differentiates the career choices of women from those of men has to do with the orientation toward people. Women strongly prefer fields in which they work with people rather than things, and hence we find college-trained women most heavily represented in the humanities, the applied aspects of the social sciences, education, and the health professions. Some of these differences persist even among men and women who have chosen the same occupational field. Women are more often found teaching science than doing science. Women college teachers mention as most satisfying about their campus jobs "good students" and "desirable colleagues," whereas men teachers stress "opportunity to do research" and "freedom and independence" (*25*).

For most American women, growing up has meant shifting from being taken care of in a well-peopled social environment to taking care of others. If we want more women to enter science, not only as teachers of science but as scientists, some quite basic changes must take place in the ways girls are reared. If girls are to develop the analytic and mathematical abilities science requires, parents and teachers must encourage them in independence and self-reliance instead of pleasing feminine submission; stimulate and reward girls' efforts to satisfy their curiosity about the world as they do those of boys; encourage in girls not unthinking conformity but alert intelligence that asks why and rejects the easy answers. A childhood model of the quiet, good, sweet girl will not produce many women scientists or scholars, doctors or engineers. It will produce the competent, loyal laboratory assistant "who will not operate so readily on her own," as Pollard wrote recently in describing his preference for a female rather than a male laboratory assistant (*26*).

Summary and Conclusions

American society has prided itself on its concern for the fullest development of each individual's creative potential. As a nation, we have become sensitive to the social handicaps of race and class but have remained quite insensitive to those imposed because of sex. Those women who have entered the top professional fields have had to have extraordinary motivation, thick skins, exceptional ability, and some unusual pattern of socialization in order to reach their occupational destinations. In their backgrounds one is likely to find a professional mother, an unusually supportive father, or dedicated and stimulating teachers.

If we want more women scientists, there are several big tasks ahead:

1) We must educate boys and girls for all their major adult roles—as parents, spouses, workers, and creatures of leisure. This means giving more stress in education, at home and at school, to the future family roles of boys and the future occupational roles of girls. Women will not stop viewing work as a stopgap until meaningful work is taken for granted in the lives of women as it is in the lives of men.

2) We must stop restricting and lowering the occupational goals of girls on the pretext of counseling them to be "realistic." If women have difficulty handling the triple roles of member of a profession, wife, and mother, their difficulties should be recognized as a social problem to be dealt with by social engineering rather than be left to each individual woman to solve as best she can. Conflicts and difficulties are not necessarily a social evil to be avoided; they can be a spur to creative social change.

3) We must apply our technological skill to a rationalization of home maintenance (*15*). The domestic responsibilities of employed women and their husbands would be considerably lightened if there were house-care service firms, for example, with teams of trained male and female workers making the rounds of client households, accomplishing in a few hours per home and with more thoroughness what the single domestic servant does poorly in two days of work at a barely living wage.

4) We must encourage men to be more articulate about themselves as males and about women. Three out of five married women doctors and engineers have husbands in their own or related fields. The views of young and able women concerning marriage and careers could be changed far more effectively by the men who have found marriage to professional women a satisfying experience than by exhortations of professional women, or of manpower specialists and family-living instructors whose own wives are homemakers.

The physiological differences between male and female are sufficiently clear and so fundamental to self-definition that no change in the direction of greater similarity between male and female social roles is going to disturb the sex identity of children or adults. No one would be confused if men were more tender and expressive and women more aggressive and intellectual. If anything, greater similarity in family and occupational roles would add zest and vitality to the relations between men and women and minimize the social segregation of the sexes. An increase in the number of women scientists would be only one of many desirable outcomes to the social changes that I have here urged.

References and Notes

1. *American Women: Report of the President's Commission on the Status of Women, 1963* (Government Printing Office, Washington, D.C., 1963).
2. *Report of the Committee on Federal Employment to the President's Commission on the Status of Women* (Government Printing Office, Washington, D.C., 1963), pp. 104–105.
3. *1960 Census of Population* (Government

Printing Office, Washington, D.C.), vol. 1, pt. 1, Table 202.
4. Scientific personnel in government employment do not show so high a proportion of women in the biological sciences: the proportion female by major scientific field among those federally employed is 8 percent for physical sciences, 4 percent for biological sciences, 1 percent for engineering (*2*, Appendix D).
5. D. Hiestand, *Economic Growth and Employment Opportunities for Minorities* (Columbia Univ. Press, New York, 1964).
6. 1962 National Register data, reported in *Physics: Education, Employment, Financial Support, A Statistical Handbook* (American Institute of Physics, New York, 1964).
7. *1960 Census of Population: Characteristics of Professional Workers* (Government Printing Office, Washington, D.C.).
8. *Ibid.*, rates calculated from data in Tables 3 and 6.
9. J. Davis, *Great Aspirations: The Graduate School Plans of America's College Seniors* (Aldine, Chicago, 1964), pp. 154–155.
10. N. Miller, "One year after commencement," *National Opinion Research Center, Chicago, Report No. 92* (1963), pp. 125–126.
11. Preliminary results of a recent questionnaire sent to the same sample as in Davis (*9*).
12. H. Martineau, *Society in America*, S. M. Lipset, Ed. (Doubleday, New York, abridged ed., 1962), p. 295.
13. H. Lehman, *Age and Achievement* (Princeton Univ. Press, Princeton, N.J., 1953).
14. A. Rossi, *Daedalus* **93**, 615 (1964).
15. F. I. Nye and L. W. Hoffman, *The Employed Mother in America* (Rand McNally, Chicago, 1963).
16. R. Hess, *J. Marriage and the Family* **26**, 422 (1964).
17. One experimental day-care center in Syracuse, New York, will test the effect of an optimal environment for 6-month-to-3-year-old children on learning readiness at school age. B. M. Caldwell and J. B. Richmond, *ibid.*, p. 481.
18. A. Roe, "A psychological study of eminent biologists," *Psychol. Monograph No. 65* (1951), p. 331; "A psychological study of physical scientists," *Genet. Psychol. Monograph No. 43* (1951); "Psychological study of research scientists," *Psychol. Monograph No. 67* (1953), p. 2; "Crucial life experiences in the development of scientists," in *Talent and Education*, E. Torrance, Ed. (Univ. of Minnesota Press, Minneapolis, 1960); *The Making of a Scientist* (Dodd, Mead, New York, 1963).
19. G. Stern, M. Stein, B. Bloom, *Methods in Personality Assessment* (Free Press, Glencoe, Ill., 1956).
20. E. Maccoby, "Woman's intellect," in *The Potential of Women*, S. Farber and R. Wilson, Eds. (McGraw-Hill, New York, 1963), gives a more detailed summary of sex differences in intellectual ability.
21. E. Bing, *Child Development* **34**, 631 (1963).
22. J. Coleman, *The Adolescent Society* (Free Press, Glencoe, Ill., 1961).
23. M. Rosenberg, *Occupations and Values* (Free Press, Glencoe, Ill., 1957).
24. J. Davis, *Undergraduate Career Decisions*, in press.
25. R. Eckert and J. Stecklein, "Job motivations and satisfactions of college teachers," *U.S. Office of Education Coop. Res. Monograph No. 7* (1961).
26. E. Pollard, *Science* **145**, 1018 (1964).

News and Comment

Kansas City: New Medical Complex, University Should Complement Midwest Research Institute

Since World War II the economic indicators have shown the Midwest to be suffering a decline in relation to the "growth" areas of the country, notably the East and West coasts, the mountain states, and the sunshine states of Florida and the Southwest. In such categories as population, income, new jobs, and share of national output the Midwest has generally fallen below national average on the growth indexes. An unfavorable pattern in the distribution of federal R & D funds has caused political rumblings in the Midwest in recent years. And one of the sorest points has been the brain drain—the loss of scientifically and technically trained people produced in large numbers at considerable expense by the state universities of the region.

A grouping of six states in the trans-Mississippi Midwest—Iowa, Missouri, Arkansas, Nebraska, Kansas, and Oklahoma—has fared even less well, it appears, than the Midwestern states of the Great Lakes region. Near the geographical center of this six-state, have-less region, and, in fact, near the center of the United States, is Kansas City, which has shared to a degree the economic travails of the states around it and sees itself not only as a transportation center and market for the area but also as the natural leader in an overdue economic resurgence.

At the upper levels, at least, the brain drain does not seem to have hurt Kansas City too badly. The operating heads of most of the major education, health, and research institutions are from outside the region and in many cases from the East or West coasts.

Kansas City, more than many places, has a tolerance of outsiders with ideas and ability. An early application of technology to business, which did much to "make" Kansas City, provides an illustration. It is said that it was an Illinois man named McCoy who, after the Civil War, conceived the idea of having cattle driven north on the long trail from Texas to Abilene and there loaded on trains for Kansas City, which was a major rail hub. McCoy convinced Kansas City businessmen to build cattle pens and loading platforms at Abilene, and the saga of the Kansas City steak began. Incidentally, another outsider, Charles Francis Adams, Jr., of the Boston Adamses, was named president of the Kansas City stockyards.

Today, even a random look at the institutions and industry in the area on both sides of the Kansas-Missouri state line which makes up the Kansas City metropolitan area reveals that new Kansas Citians are ubiquitous. Dean of the University of Kansas Medical School is Arden Miller, who joined the faculty in the 1950's from the Yale medical school. President-elect of the University of Missouri at Kansas City (which until 2 years ago was the privately supported University of Kansas City) is physicist Randall M. Whaley, who was born in Hastings, Nebraska, but spent nearly 2 decades of his career at Purdue and is currently vice-president for graduate studies and research at Wayne State University in Detroit. Director of the Linda Hall Library of science and technology (*Science*, 21 May) is Joseph C. Shipman, who came to Kansas City 20 years ago from Ohio via Baltimore. Executive director and chief surgeon of Menorah Hospital, a private hospital with ambitious programs in preventive medicine, research, and medical education, is Martin E. Silverstein, an energetic proponent of measures to insure that new medical and surgical techniques are widely and safely applied. Silverstein is a graduate of Columbia College and was associate dean of New York Medical College before going to Kansas City. Kansas City's congressman, Representative Richard Bolling (D–Mo.), was born in New York City, and grew up in the South. He went to Kansas City after the war to take a job in the university's administration