Members of the American Association of University Women (AAUW) and other proponents of the Equal Rights Amendment demonstrate in front of the White House, March 22, 1977. (UPI-Bettmann/Corbis)

by, women have been summed up nicely by Henry Etzkowitz, Carol Kemelgor, and Brian Uzzi: "The human price for the Ph.D. is higher for women than for men, and the rewards are often lower" (Etzkowitz et al. 2000, 95). Although international variations existed, the similarities in women's experiences were virtually universal. At every stage of their education, girls were reminded of their differences from men and of their lesser status in western society. Women were taught that they should not be naturally inclined toward science, and that women who are good at science are not feminine. Many women overcame these barriers and disadvantages and entered undergraduate, graduate, and post-graduate science studies, but at each level a significant number of women dropped out. This state of affairs is generally referred to as the "leaky pipeline." Though the second half of the twentieth century saw increasing numbers of women taking science degrees and obtaining employment, the numbers of women present at each career stage decreases. In Europe in 1997, an almost equal number of men and women took science degrees, yet very few women obtained top positions in science. The male culture of the university, university departments, and science laboratories, both on and off university campuses, constrained women.

There have been periods of time and particular places in the second half of

the twentieth century when women were welcomed into science practice. During World War II, as had been in the case in World War I, the absence of men from universities and industry allowed women to enter fields that were inaccessible during the inter-war period. Women received a higher number of Ph.D.'s in this period than they had previously, although men still received a higher percentage of the degrees than women, and men's participation in science increased at a much higher rate. During the war, women entered university positions, albeit often as part-time replacement faculty, and benefited from increased science funding.

Although women were encouraged to leave their positions after World War II, the Cold War motivated the U.S. government to encourage women to study science as a matter of urgent national military priority. The government feared that as men were needed elsewhere, especially as the Korean War began in 1950, there would be a shortage of highly trained scientific personnel. This was an important move by the government for women, as it was not perceived as a temporary war measure but as an effort to permanently move more talented women into science. Yet women in the 1950s received a conflicting message, one that simultaneously urged them to conform to traditional roles. Many government jobs in science were connected to the military, so sexism was rife, and women were kept out of top jobs, were paid lower salaries than they would have received in industry, and were not, for example, allowed to be trained for particular jobs, such as astronauts. Still, many women scientists were pleased to work in government science because industrial managers often discouraged them from working in industry. With the end of the Cold War in 1991, and thus declining military research, positions became limited, and women again were squeezed out of jobs.

Women scientists in the post–World War II period continued to utilize many of the same tactics that women scientists before them used to access scientific careers. Some lived and worked on the margins of science, accommodating their scientific work to family life and their husbands' careers. Others worked within feminized fields of science or in women's colleges, or found other niches outside of the most obvious and prestigious environments. Despite the drawbacks, some women formed support groups, women's clubs, and women's science prizes.

The idea of the lone male scientist affected many women's belief in their capacity to practice science. There has been a strongly held image among scientists that the successful male scientist works alone to make substantial scientific breakthroughs, that his best work will be accomplished early in his career (before he is forty years old), and that in order to achieve success in science he must dedicate his life to its pursuit. Feminists argue that the belief that men work alone to achieve scientific success is a myth of the scientific establishment. In fact, in the twentieth century, science increasingly became a team-orientated profession. In the laboratory, work was done collaboratively. The successful

male scientist became part of a scientific network of graduate students and academic and industrial scientists early on in his career. Likely his supervisor introduced him into the necessary scientific circles and invited him to conferences. The male science student also likely extended and possibly even created new networks from his own contacts at school and beyond. This networking was often done in a social setting during sports activities, get-togethers after hours, or study groups set up among graduate students.

Uninitiated women scientists often accepted the myth that to be a successful scientist they would have to work alone and succeed alone while men took advantage of a supportive network of colleagues. Those women who perceived the necessity of joining a team sometimes found it difficult to be accepted into such a group. Male supervisors often failed to introduce their women students into the necessary circles or to invite them to important talks or to join a research group. Australian physicist Rachel Makinson, researcher at the CSIRO Division of Textile Physics, noted that "I mostly had to work by myself," except on one occasion when the chief wanted some work done quickly; she was "never given a team." When asked if she believed that this was because she was a woman scientist in a male-dominated environment, she said, "I think so—but one can't prove these things" (quoted in Bhathal 1999, 131). Whereas women have often been successful in high school science due to the support and encouragement of a particular teacher or parent, they tend to lose this personal contact at the university level and thus often felt discouraged by their isolation. Women have either not been invited to or have felt uncomfortable in the social situations in which networking connections and decisions are made. As a result, they have been excluded from the team environment in which they would very likely thrive if only they could gain access. Instead they have often been left to struggle alone, failing to complete their studies or achieve their research goals.

The male-orientated workplace further disadvantaged women by failing to accommodate their biological life cycle. If scientists assumed that they must achieve success early in their career and dedicate their early adult life to science, then women in their twenties and thirties found themselves at a marked disadvantage. Women who gave birth and took time off to raise children were often considered a loss, or at best not believed to be as serious or committed scientists as their male colleagues who have dedicated their lives fully to science by living, sleeping, and eating around their research work. Microbiologist Nancy Millis, although herself not married and remaining childless, recognized that it is the "biological problem of children" that creates a differential between men and women. If, she speculated, "a large factory or large university [had] a really good child care place which was there from 8 in the morning to 7 at night, and you could leave your child there in the total understanding that it was well looked

after, then that would make a big difference, in my view, to what women could do" (Bhathal 1999, 52). Female supervisors could be as equally guilty of disadvantaging women. One female faculty member in the research by Etzkowitz, Kemelgor, and Uzzi stated: "If a student had a baby with her, I wouldn't have her. Students who have babies here get no work done. It's not that I wouldn't take a woman with a child in the first place, but the first sign of trouble, I would just tell them to go away. If my students fail it looks bad for me" (2000, 89). The assumption that the best work is done early on in one's career and by denying oneself a life outside of the workplace meant that a woman who took time out to have children might fail to graduate, to obtain a job, to obtain tenure as quickly, or to obtain it at all. Women who took time out of their career for their children often eventually achieved tenure and the various accolades of their profession, but these came later in their profession, and the chances of achieving high status, high-level positions, awards, or comparable pay increases to those of men of the same age and with the same achievements were reduced.

Women were also constrained in their ability to move from job to job, and place to place, because of their partners' careers. Though there have been an increasing number of dual-career couples in the academic and professional worlds, women's careers have repeatedly taken second-place to their partners' careers, especially if they had children. In part this might be a financial decision, as more often than not men made more money than women, even when both were successful professionals. Such decisions may be based on child-care needs, often linked to the continued stereotypical tradition that a man's career should come first. Whereas men were able to wait until later in their careers to marry and have a family, women's biological time clocks conflict with the tenure time clock. Some women opted not to marry or have children, and others gave up science in order to fulfill these needs in their lives. In short, for women, there has been no "right time" to have children on the academic career track.

However, in the United States in 1972, Congress, encouraged by working women who had sent petitions and spoken out against inequities for women in the workplace that contravened the equal pay and sex discrimination legislation, passed the Equal Employment Opportunity Act. As a result, educational institutions were no longer exempt from equal employment opportunity laws, and women could not be discriminated against on the basis of their sex in federally assisted programs including sports, textbooks, the curriculum, and in education employment. The equal pay act was extended to cover administrative, professional, and executive employment, and the United States Commission on Civil Rights' jurisdiction was extended to include sex. The United States was not alone in taking this kind of legislative action. Most western countries adopted similar antidiscrimination laws.

Yet, even as the legislation was being enacted, the search for an increased number of professional scientists was coming to a halt as science budgets were cut and Defense Department monies could no longer be spent on university research. For the first time in many years, the number of scientists employed by the U.S. federal government decreased. A glut of doctorates appeared on the market in the 1970s, and a crisis mentality ensued that blamed, in part, the number of women who had achieved doctorates in the 1960s. By the 1980s, affirmative action was not rigorously enforced in most industrialized nations and as a result had little effect on recruitment or retention of women in science. Moreover, women were often told, after starting work in a new position, that they had attained the job to fill a gender quota, not due to their accomplishments. Naturally, women felt unwelcome, and this situation affected some women's self-confidence.

Over time, not only have women's careers been thrown by the wayside, but the status quo has persisted. Male professors set examples for their male graduate students about how to behave toward female graduate students and how male supervisors advised women. Moreover, they recreated a scientific world that often disadvantaged men who would like to balance their career and personal lives more equally. Though women often made the sacrifices necessary to gain access to and succeed in a career in science, more recently they have made different decisions. Some women science students examined the lives of the female role models, looked askance at the sacrifices they made, and decided that they did not want such a life for themselves. Even women who achieved moderate success in a science career opted not to take on the heavier responsibilities of a higher-level career position so that they could have both a career and a family life. As a result, though women's numbers in science increased, women often remained in low-level positions, unable to change the status quo for those women who followed. Thus, women's failure to progress in their careers often related to both conscious and unconscious reactions to the sexism found in much of science.

The Feminist Critique of Science

Feminists generally agree that in western society gender is a highly significant factor dictating human behavior, the nature of human relationships, and the formal and informal laws by which societies live. Beginning in the 1960s, the second wave of the feminist movement explored how patriarchal societies disadvantaged women, both to reveal and correct inequalities between the sexes. Just as the movement was never monolithic despite the spirit of cooperation between

anced view of Rosalind Franklin's life and work in *Rosalind Franklin: The Dark Lady of DNA* (2002). Sayre portrays Watson and Crick as the "winners" and Franklin as the "loser." Though not denying the mistreatment of Franklin at the hands of her male colleagues, Maddox nevertheless suggests that Franklin herself was likely more disappointed by her early death, which cut her research time short. Just as Susan Quinn painted the portrait of the whole woman—Marie Curie—Brenda Maddox painted the bigger picture of Franklin's life and work. Maddox suggests that Franklin's Jewish heritage and upper-middle-class background, as well as her sex, contributed to her poor relations with her King's colleagues. She also points out that Franklin chose to remain unmarried and childless to pursue her career, but that she did indeed experience love, and close and enduring friendships with men and women. Maddox also emphasizes the success of Franklin's work after her time at King's. She was so much more than the talented crystallographer who made beautiful X-ray photographs. Franklin was successful in obtaining significant funding for her group at Birbeck College. Working in a supportive, stimulating, and collegial atmosphere there, she published a significant number of papers and became a world leader in the study of virus structure by X-ray crystallography.

Rosalind Franklin practiced science in the period between World War II and the rise of the second wave of the feminist movement. Increasing numbers of women were entering science during this period. Access to the requisite education, increased number of jobs at growing universities, and industrial and technological advancements expanded employment opportunities for women scientists. However, institutional and cultural barriers still continued to hinder women's work in science. Throughout the 1970s and 1980s, feminists began to critique science as a discipline and to call for change. Their work led to a consciousness-raising among university faculty and administrators, employers, the general public, and women scientists. Despite obstacles to working in science in the second half of the twentieth century, the numbers of successful women in science grew exponentially, as did the numbers of men, and women's contribution to scientific research grew accordingly.

Barriers to Women's Participation in Science: History Repeats Itself

Despite women's interest in and intellectual capacity to practice science, and despite legislation that should have enabled women to achieve equality with men, women in the second half of the twentieth century still faced many of the same barriers women faced one hundred years earlier. Prejudices against, and struggles