A Pathways Model

for Career Progression in Science

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Before the issue of the underrepresentation of women in the research ranks of the basic sciences can be addressed, it is necessary to understand the extent to which the problem exists, and what possible obstacles to career progression may be present. While the educational path for scientists is often thought of in terms of a "pipeline" that students "flow" through or "leak" from, data suggests that the progression from grade school directly to the Ph.D. is not linear. Rather, individuals often take different avenues to an eventual independent research career.

To address the dynamics of the rates of career progression, exit and re-entry to the career path, I have developed a Pathways Model for study of the career track of a U.S. researcher, focusing from high school to independent investigator in the basic sciences. This Pathways Model, Figure 1, is patterned after traditional biochemical models for enzyme reactions. It looks at career progression as a dynamic system, with measurable rates for progression up the career ladder, and delineates points to effectively leverage these rates or recover losses akin to biochemical "salvage pathways."

Data for women in the disciplines of chemistry and biology, as they progress through the career pathway (as compared to their male counterparts), are from the indicated references. Changes in the rates of progression for women in chemistry and biology over time are provided for comparison, as an indication of the present state of this system. The National Institute of General Medical Sciences, Office of Program Analysis and Evaluation's, Ms. Christina Zimmerman and Dr. James Onken, Chief, furnished the information on the demographics of high school and college graduates, as well as the data on the demographics of NIH awards. The efforts of Ms. Zimmerman and Dr. Onken in helping to prepare the demographic data used in this report are gratefully acknowledged.

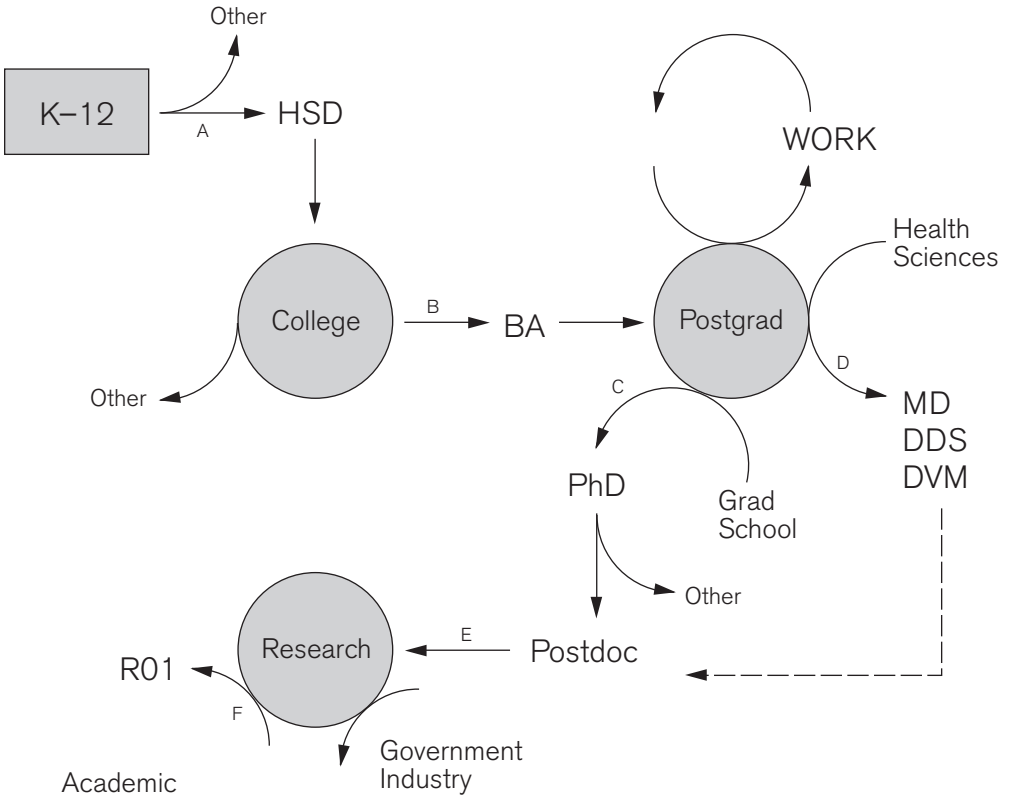
Pathways Model

Step A

- Women make up 52 percent of the U.S. population and earned 51 to 52 percent of the more than two million high school diplomas awarded for the period, 1982 to 1994.
- 1982: 2.84 million high school diplomas were awarded, 52 percent earned by women
- 1990: 2.75 million high school diplomas were awarded, 52 percent earned by women
- 1994: 2.40 million high school diplomas were awarded, 51 percent earned by women

Reference: U.S. Department of Education, National Center for Educational Statistics. The 1994 High School Transcript Study Tabulation: Comparative Data on Credits Earned and Demographics for 1994, 1990, 1987 and 1982 High School Graduates, Revised NCES 99-532, by Stanley Legum, Nancy Caldwell, Bryan Davis, Jacqueline Haynes, Telford J. Hill, Stephen Litavecz, Lou Rizzo, Keith Rust, and Ngoan Vo. Project Officer, Steven Gorman, Washington, D.C.: 1998. (http://nces.ed.gov/pubs98/98532.pdf)

Figure 1 Pathways Model



Step B

- Over the past 20 years, the percentage of bachelors' degrees in biology or chemistry being earned by women has increased steadily.
- In 1981, women earned 30.1 percent of the 11,540 bachelors' degrees awarded in chemistry and 44.5 percent of the 44,046 bachelors' degrees awarded in biology.
- By 1996, women earned 41.5 percent of the 11,137 bachelors' degrees awarded in chemistry and the majority (52.9 percent) of the 62,081 bachelors' degrees awarded in biology.

Note that while the total number of degrees being awarded in chemistry in 1981 to 1996 has remained rather constant, the percentage of these degrees being awarded to women has increased 11.4 percent since 1981. In biology, the number of degrees awarded to women since 1981 has increased by 8.4 percent.

Reference: U.S. Department of Education, National Center for Education Statistics (NCES), Integrated Post-secondary Education Data System (IPEDS). Data restricted to U.S. Citizens and Permanent Residents.

Step C

- The number of women earning a Ph.D. in chemistry or biology has increased steadily over the past 20 years.
- In 1981 women earned 15 percent of the 1,329 doctoral degrees awarded to U.S. citizens and permanent residents. By 1996, women earned 30 percent of the 1,461 doctoral degrees awarded in chemistry.
- Similarly, in 1981 women earned 29.1 percent of the 3,420 doctoral degrees awarded in biology. By 1996, women earned 44.5 percent of the 4,365 doctoral degrees awarded in biology.

The demographics of women earning the terminal degree in 1998 is similar to that of their male counterparts. Both women and men are taking 7 years to obtain a Ph.D. in biology and 6 years to obtain a Ph.D. in chemistry. The median age of women and men obtaining the Ph.D. in biology is 32 years, while the median age of women and men obtaining a Ph.D. in chemistry is 29 years. Slightly more men than women earning the terminal degree were planning on doing additional postdoctoral training upon completion of their degree. In biology, 54.4 percent of men and 50.6 percent of women were planning on pursuing postdoctoral training, while 49 percent of male chemists and 44.6 percent of female chemists were planning on postdoctoral work.

Reference: National Research Council (NRC) Doctorate Records File (DRF). Data restricted to U.S. Citizens and Permanent Residents and NSF/NIH/NEH/USED/USDA, Survey of Earned Doctorates, 1998.

Step D Medical schools enroll approximately 16,000 students each year. The percentage of women attending medical school rose from 9 percent in 1970 to 44 percent at present, and more than 90 percent of those entering medical school complete their medical degrees.

Reference: Association of American Medical Colleges (AAMC) Data Book. Statistical Information Related to Medical Schools and Teaching Hospitals, Issues from January 1991–1999.

Step E The demographics of faculty in the basic science departments of medical schools is reviewed annually by the Association of American Medical Colleges. Comparison of the demographics, at all faculty levels, between 1990 and 1999 reveals that the number of basic science faculty at medical schools increased by 937 positions from 1990 to 1998, with 349 (37 percent) of these positions filled by women. Similar to the 1990 demographics, the bulk of the women in basic science faculty positions at medical schools were at the instructor and assistant professor level in 1998. Slight gains over the 1990 levels (approximately 5 percent) at the associate and full professor levels were made in 1998.

- In 1990, 216 (40.9 percent) of instructors on the basic science faculty at medical schools were filled by women. In 1998, 302 (41.9 percent) of these positions were held by women.
- In 1990, 1,034 (29.3 percent) of assistant professors on the basic science faculty at medical schools were women. In 1998, 1,333 (32.8 percent) of these positions were held by women.
- In 1990, 669 (19.2 percent) of associate professors on the basic science faculty at medical schools were women. In 1998, 917 (25.4 percent) of these positions were held by women.
- In 1990, 410 (9.7 percent) of professors on the basic science faculty at medical schools were women. In 1998, 759 (13.6 percent) of these positions were held by women.

Reference: Association of American Medical Colleges (AAMC) Data Book. Statistical Information Related to Medical Schools and Teaching Hospitals, Issues from January 1991–1999.

Step F

Independent academic researchers must obtain outside funding to progress their research programs. Looking at NIH application and award rates for investigators not previously supported by NIH, more than twice as many men as women applied for NIH First Awards (R29 awards) between 1988 and 1997. However, women competed as well as their male counterparts in obtaining these awards. The average award rate for both women and men over the 10-year period, 1988 to 1997, was 26 percent.

The number of competing Individual Investigator Research Project Grant (R01) applications submitted by women grew from 2,401 in 1988 to 3,172 by 1997. In 1988, men were submitting more than four times as many competing applications to NIH as were women. By 1997, men were submitting only a little more than three times as many applications as women. In terms of competing R01 awards made, women have been as successful as men in obtaining funding. Women averaged an 18 percent award rate for competing NIH R01 applications from 1988 to 1997, while men averaged a 17.8 percent award rate.

Similarly, for competitive renewals of existing NIH R01 awards over the period 1988 to 1997, women have been only slightly less successful than their male counterparts in renewing their awards. During the 10-year time period of 1988 to 1997, women averaged a 35 percent success rate for competing R01 applications, compared to a 36 percent success rate for men over the same time.[5]

In summary, women have made steady gains in the number of undergraduate and doctoral degrees they are earning in both biology and chemistry. As of 1996, women, who make up 52 percent of the U.S. population, were earning 41.5 percent of the bachelors' degrees and 30 percent of the doctoral degrees in chemistry, as well as 52.9 percent of the bachelors' degrees and 44.5 percent of the doctoral degrees in biology. Women complete their graduate work in the same amount of time as their male counterparts. They pursue postdoctoral studies at similar rates, and compete as effectively for NIH funding as their male peers, when they apply. However, the percentage of NIH R01/29 individual Research Project Awards earned by women has increased only slightly over the past 10 years, from 18.3 percent in 1988 to 22.3 percent in 1997, and the promotion of women to senior (Associate Professor/Professor) career levels has been slow.

[5] The National Institute of General Medical Sciences, Office of Program Analysis and Evaluation. Dr. James Onken, Chief, provided data on the demographics of NIH awards.