There are four sections to the book; the primary *raison d'être* is Payne-Gaposchkin's autobiography, "The Dyer's Hand." This is preceded by personal recollections by Haramundanis of her parents and brothers and her view of the cast of characters at Harvard Observatory. The two introductions are interesting in providing two different perspectives of Payne-Gaposchkin and her work. The first, by Jesse L. Greenstein, draws in bold strokes a picture of physics in the early 1920's. The emerging view of the atom and the uncertain chemical origins of Earth, Sun, and stars were united in one thesis, in which Payne-Gaposchkin brilliantly demonstrated that all stars had nearly constant compositions. In addition, she found that stellar atmospheres showed enormously larger amounts of hydrogen and helium compared with abundances found in meteorites. Her superiors held a conservative view, however, and she wrote in her thesis that "the enormous abundance derived . . . is almost certainly not real," thus bowing to authority and doubting her own remarkable results. She was of course vindicated within five years. Greenstein, himself an eminent astrophysicist, describes Payne-Gaposchkin as an "extraordinary figure" with a deep "intuition as to what was important in astronomy."

The second introduction is by science historian Peggy A. Kidwell, who focuses on the thesis years 1923–1925. Kidwell has dredged up original letters of reference written to Shapley by Payne-Gaposchkin's Cambridge University mentors Eddington and Comrie. They spoke glowingly of her "wide knowledge" and enthusiasm. Curiously, Comrie added that "she would not want to run away after a few years training to get married." To present-day opinion this seems a questionable statement, but in 1923 it could only have been meant as a compliment. She accepted the small stipend offered by Shapley and thus began the half-century-long association with Harvard. Kidwell writes of Payne-Gaposchkin's earliest months of "utter bewilderment" as she struggled to understand her new data and of how, two years later, she had written six papers and the monograph on the ionization potentials of many elements and the temperatures, spectra, and abundances in the atmospheres of OB stars. The great Henry Norris Russell wrote of her that she was "quite the best of the young folks" in astrophysics, though even this was not enough for a young woman to get a job in those days. Kidwell airs a letter from Payne-Gaposchkin's unhappy years as she moved "upward" into teaching and lecturing at Harvard. She wrote, "I cannot appear in the catalogues; I do give lectures, but they are not announced in the catalogue, and I am paid for (I believe) as 'equipment.' " Shapley did make some improvements in her salary and working conditions, but the president of Harvard refused her the listing as instructor. It was not until she was 56 that she achieved an appointment as full professor, the first woman to obtain this rank at Harvard.

In "The Dyer's Hand" Payne-Gaposchkin writes, "If I have made a contribution, it has been by collecting, turning over in my hands, comparing and classifying the data of astronomy." Clearly, she had a genius for assimilating and unifying great masses of data, whether they concerned the atmospheres of massive stars, light curves and orbital elements of variable stars, or spectrophotometry of novae. Her autobiography, written in her 70's, consists of a long look backward, with much detail lavished on her childhood and early education in England, her life at Harvard under Shapley, and her passion for science. We find her enthralled upon hearing a lecture by Eddington on his verification of Einstein's theory of relativity; we sense her idolization of Shapley (though she presents a realistic view of him). We see her grow from a shy, highly talented child inspired to learn botany to the much honored scientist emerita.

As the book progresses, one wishes that the later chapters were as detailed as the first ones. One feels that they existed as notes to be worked in somewhere when they were fully developed. In spite of this, there are many gems strewn throughout the book; these from one who overcame vexing obstacles and who has illuminated with starlight the path for many scientists to come.

Cecilia Payne at Radcliffe College, 1924. [From *Cecilia Payne-Gaposchkin: An Autobiography and Other Recollections*]

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Scientific Educations

Four Lives in Science. Women's Education in the Nineteenth Century. LOIS BARBER ARNOLD. Schocken, New York, 1983. xii, 179 pp., illus. $14.95.

When Maria Martin (later Bachman) collaborated with John Audubon, drawing flowers and plants as background for his bird illustrations, she demonstrated not only her artistic talent but also a thorough knowledge of natural history. Lois Barber Arnold examines the lives of Martin and three other women whose lives typified their generations, but whose accomplishments were exceptional. Her assumption is that the history of education, in the spirit of current work at Columbia University initiated by Lawrence Cremin, must go beyond school teaching to the total environment from childhood into adulthood. Rather than stress the larger limitations placed on women interested in science, she uncovers the informal opportunities that a few enterprising women mobilized into productive contributions. Each woman's life follows a distinct pattern, one consistent with her own time and place.

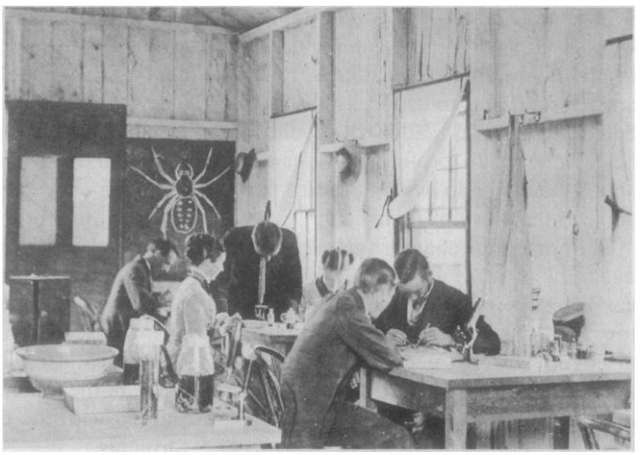
Maria Martin was surrounded by discussions of natural history in the Charleston household where she helped an invalid sister raise a family. She accompanied her brother-in-law, the active naturalist and Lutheran minister John Bachman, on field excursions and learned to describe plants and animals in scientific terms. Her opportunity came when Audubon visited for months at a time in the 1830's in order to work on southern examples for his *Birds of America*. Having learned scientific illustration assisting Audubon, she put this skill to use on John E. Holbrook's five-volume *North American Herpetology*. Private, informal study, acquired through family connections rather than systematic schooling, provided some women interested in science the requisite skills. In a fascinating footnote (note 47, p. 149) the author points out recent work in experimental psychology that suggests a link

between the cognitive styles of artists and scientists. Thus, she indicates, "Women who might have been scientists become artists instead." Whatever the connection between art and science, Maria Martin was only one among several significant women illustrators in antebellum America.

For Almira Hart Lincoln Phelps, the necessary contacts with men in science came through informal boardinghouse conversations and public lectures. Sister to Emma Willard, the innovative founder of Troy Female Academy, Phelps was also encouraged by Amos Eaton of Rensselaer Polytechnic Institute. She wrote scientific textbooks and in several female academies taught her students the basics of botany, chemistry, and natural history more generally. Education became the major outlet for women intellectuals in the last half of the century.

Louise C. Allen (later Gregory) developed a program in home economics that predated that of Ellen Richards. Allen faced the increasingly articulated strictures against women studying science, such as those of Herbert Spencer, and took a teaching degree from the Illinois Normal School in Bloomington. After several years of school teaching and administration she headed the School of Domestic Science at the University of Illinois from 1870 to 1878. Having no access to an advanced degree, she upgraded her education by lectures, institutes, and summer school programs: health and physical education training at the University of Pennsylvania, physiology from Mary Blake at the Gannet School and chemistry at Harvard University in the Boston area, and food chemistry at the National School of Cookery in London. From this ad hoc study she developed a comprehensive program for the women at Illinois that existed for nearly a decade. By the time Florence Bascom took her Ph.D. degree from a reluctant Johns Hopkins University in 1893, women had gained limited access to advanced education. Her subsequent teaching career at Bryn Mawr led to a sequence of prominent women geologists whose connection to scientific education was at once both formal and personal.

The chapters on these women are, to use a 19th-century phrase, "familiar essays." We learn of family and friendships among women who, like men, relied on networks for support but whose connections were different. A domestic ideology meant that dynamic relationships seem at once to be more personal and intimate but less powerful and useful than those experienced by men. That fact is poignantly illustrated by the observation that these women, including Bascom to some degree, probably did not reach the mature production or the recognition accorded their male peers. In fact, the male connections remain ambiguous. Of these four women, Martin and Allen did little in science after their late marriages, Phelps spent considerable years as a widow, and Bascom never married. It appears that while 19th-century parents and siblings could provide support husbands and children were likely to be impediments. Other issues, too, require more systematic investigation. It remains an enigma, for example, why, if personal local factors were dominant, there were so few other daughters in science. If opportunities for formal education became increasingly important, why is the legacy of Phelps and Allen for individual students so uncertain?



Interior of the laboratory for the Summer School of the Peabody Museum of Salem, 1876. Women used informal institutes and summer schools like that pictured here to improve their skills in science. [Courtesy of Peabody Museum of Salem]

This book lacks the breadth of Margaret Rossiter's already classic *Women Scientists in America: Struggles and Strategies to 1840*, but it contributes a divergent point of view. Here we learn in intimate detail of the personal context that shaped the interests and defined opportunities of women interested in science. By reminding readers of the fullest meaning of education, Lois Barber Arnold points out that classroom study will never be sufficient to guarantee the recruitment and productivity of women in science.

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The Fundamentals of Physics

The Discovery of Subatomic Particles. STEVEN WEINBERG. Scientific American Library, New York, 1984 (distributor, Freeman, New York). xvi, 206 pp., illus. $27.95.

This book grew out of courses taught by the author at Harvard University and the University of Texas that were designed to acquaint students with no background in physics or mathematics with the great achievements of 20th-century physics. The present volume deals with the discovery of the electron, the determination of the atomic scale, and the discovery of the nucleus. Possible future volumes may cover such topics as quantum mechanics and relativity.

Attempts to present modern physics to the general reader immediately run into a fundamental problem. If one starts by first presenting all of the necessary background material on classical physics there is an excellent chance of losing most of one's audience. If, on the other hand, one goes directly to the more interesting topics the lack of background often forces the presentation to be superficial. This book utilizes an interesting compromise approach. It plunges directly into the first major theme, the discovery of the electron, but it contains a number of "flashback" sections in which the necessary classical physics is developed in detail as it is needed. The presentation is largely nonmathematical; there are a relatively small number of equations written out in words (on such topics as Newton's laws), but they can be omitted without loss of continuity