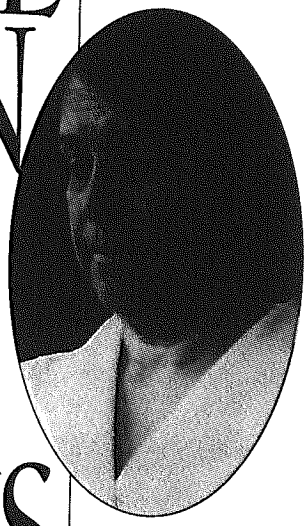
1-1-1996

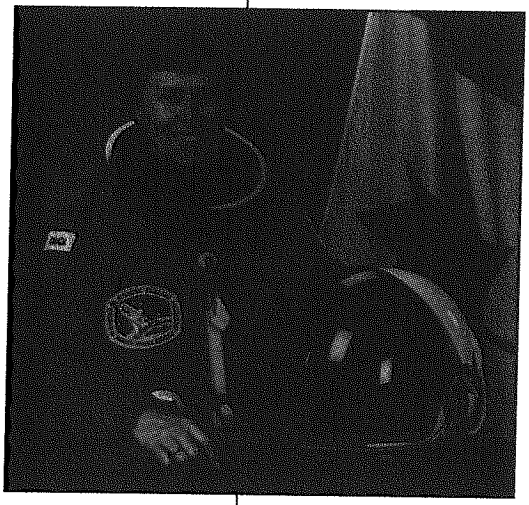
Rosalind Elsie Franklin (1920-1958) Biologist

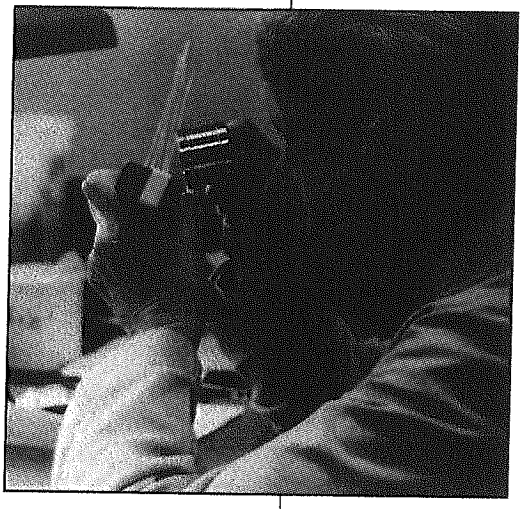
Margaret Sylvia
St. Mary's University, San Antonio, TX, msylvia@stmarytx.edu

NOTABLE WOMEN *in the* LIFE SCIENCES

A Biographical Dictionary







Edited by
Benjamin F. Shearer and
Barbara S. Shearer

Bibliography

Cattell, John McKeen, ed. *American Men of Science,* 7th ed., s.v. "Foot, Katherine." Lancaster, Penn.: The Science Press, 1944. (See also the first six editions.)

Kass-Simon, G. "Katherine Foot and Ella Strobell: 'Worth a Thousand Words.' " In *Women of Science: Righting the Record,* eds. G. Kass-Simon and Patricia Farnes. Bloomington: Indiana University Press, 1990.

Morgan, Thomas Hunt. *The Mechanism of Mendelian Heredity.* New York: Henry Holt and Co., 1915.

Mozans, H.J. *Woman in Science.* Cambridge, Mass.: MIT Press, 1974.

Ogilvie, Margaret. *Women in Science.* Cambridge, Mass.: MIT Press, 1986.

Rossiter, Margaret. "Women Scientists in America before 1920." *American Scientist* 62 (May–June 1974): 312–23.

FAYE A. CHADWELL

ROSALIND ELSIE FRANKLIN

(1920–1958)

Biologist

Birth	July 25, 1920
1945	Ph.D., Cambridge University
1947	Began work at Laboratoire Central des Services Chimiques de l'État, Paris
1951	Began work on DNA at King's College
1953	Moved to Birkbeck College; publication of Watson/Crick structure of DNA appeared in *Nature*
Death	April 16, 1958

Rosalind Elsie Franklin lost the race to discover the structure of DNA (deoxyribonucleic acid) before she fully realized that she was in a competition. DNA is the substance in cells that records the genetic structure of all living things and enables them to pass on their traits to their offspring. On February 23, 1953, Franklin recorded in her laboratory notebooks that DNA had a helical structure of two chains. She had previously deduced that the phosphates in the structure must be on the outside of the chains, leaving the base-pairs on the inside. By the time the manuscript recording this was typed for submission on March 17, 1953, the

race was over.[1] On March 6, 1953, James Watson and Francis Crick had submitted their description of the structure of DNA to *Nature.* Their paper, however, contained two more vital points about the structure of DNA: the way in which the bases paired off, and the fact that one chain of the helix runs up whereas the other runs down. On March 18, 1953, Franklin received a call from the editors of *Nature* regarding her interest in submitting a paper to accompany the Watson-Crick effort.[2]

As a child, Rosalind Franklin demonstrated an analytical mind and intense interest in the physical world through her preference for carpentry and building sets over dolls and games of make-believe. She attended St. Paul's Girls' School in London and spent part of one semester in Paris improving her French. At age 15 she had already decided to become a scientist, owing in part to the physics and chemistry classes offered in the rigorous St. Paul's curriculum.

Her father touched off an intense family argument when he refused to pay for her education at Cambridge, because he disapproved of women receiving a university education. Alice Franklin, Rosalind's favorite aunt, and Muriel, her mother, both informed Ellis Franklin that they would pay for Rosalind's education out of their own family money. Rosalind never entirely forgave her father, although he finally did grudgingly agree to pay for her university education.

In 1938, Franklin entered Newnham College in Cambridge University, where she became friends with Adrienne Weill, a distinguished physicist who had worked with Marie Curie. Franklin's Ph.D. research on coals and carbons during World War II helped establish the science of high-strength carbon fibers. The developing field of X-ray crystallography then attracted Franklin's attention as a way of revealing the positions of atoms in matter. In this technique, X-rays are aimed at crystalline solids and the reflections of the X-rays are recorded on film. Franklin began to use the technique on carbons and biological molecules, although it was traditionally used on simpler crystals.[3]

Weill found Franklin a job in Paris after World War II ended. After the war years in England, during which she was often terrified by air raids on her bicycle trip to and from work, she began to travel freely around the continent with her co-workers both male and female. Franklin disliked formal occasions, although she loved small gatherings, where she sparkled with wit. She enjoyed gossiping about love affairs, shopping at street markets, and playing French word games.[4]

She spent three years at the Laboratoire Central des Services Chimiques de l'État before returning to England in 1950. She was offered a fellowship at King's College in the University of London by John Randall to analyze DNA using her expertise in X-ray crystallography. At the time, DNA was known to carry the genetic code from one generation to another, but its structure was a mystery.

Franklin drew the DNA fibers apart and bundled them in parallel, because a single fiber was too thin to create a useful picture. As she continued her experiments, she found humidity to be a key component in producing a quality photograph. At 75 percent humidity in the air, Franklin produced pictures of DNA she called the dry A-form; good, detailed photographs were produced. At 95 percent humidity, however, the wet B-form of DNA showed fewer details, but a definite cross shape was manifested. The simple cross is the characteristic shape produced in X-ray crystallography by a helical structure. Franklin concluded that the phosphate sugars known to be in DNA were located on the outside of the molecule because the molecule could absorb water and desiccate so quickly.

Maurice Wilkins was second in command in the department and also was interested in DNA. He and Franklin got along at first, but their relationship deteriorated during the fall of 1951. The lab group generally worked as a team and published together, but Franklin felt she was being treated as a highly paid technical assistant and refused to share her data with others for analysis. In November 1951, Franklin gave a presentation of her work at King's College, which was attended by James Watson. The American Watson was also interested in the structure of DNA and was collaborating with Francis Crick, an English graduate student at Cambridge. In marked contrast to her gaiety in France, on her return to England she was described by Watson as being without warmth or frivolity.[5]

Watson took no notes at the presentation but, along with Crick, produced a model of the DNA molecule using parameters he remembered somewhat incorrectly from the lecture. Franklin spotted several mistakes when she viewed the model. A few months later, a government report by Franklin that summarized her colloquium was passed to Watson and Crick by Max Perutz, a member of the government agency's review committee. Crick realized after reading the report that one of the chains of the DNA helix must go up and the other down. The correct water content and location of phosphate sugars were also noted in the report.

During this period, Franklin was struggling to solve the structure of DNA through a Patterson analysis that helped her obtain accurate parameters for the unit cell but did not, in the end, give appropriate information for solving the structure. Franklin considered and discarded cylinders, double sheets, and figure eight structures. Only a few weeks after she finally turned her attention to single and multiple helices as possible structures did she learn that Watson and Crick had built a model that solved the structure of the B form of DNA. She expanded and revised a draft paper written with Raymond Gosling to appear in the same issue of *Nature* as did the Watson and Crick paper on their model.

Even before these papers were published, Franklin left King's College to work for John Desmond Bernal at Birkbeck College in the University of London. Bernal and Randall agreed that Franklin could bring her fellowship and become head of her own research group, but could not work on DNA. Despite this, Franklin finished her work on DNA at Birkbeck and began a study of tobacco mosaic virus (TMV).

Over the following years, Franklin became good friends with Crick and his wife Odile and traveled with them through Spain. During the summer of 1956 she was diagnosed with ovarian cancer, and she went through three operations and experimental chemotherapy during the next two years. At one point she convalesced with the Cricks, although she gave them no details about her illness. Only her close family and research group were told.

Franklin was a very private person, not given to easily discussing her personal problems—even with friends. Her cancer had not been diagnosed until it was far advanced because of her propensity to ignore pain, although ovarian cancer can be intensely painful. As a child, her parents had sent her to a convalescent boarding school to recover following severe bouts of flu. Franklin was very unhappy at the school, and this episode may have influenced her in her efforts to ignore painful health problems. She once walked several hours to a hospital in extreme pain when a needle became stuck in her knee.[6]

Rosalind Elsie Franklin died on April 16, 1958, within a few minutes of the time her last paper was to be read at the Faraday Society.[7] She was 37 years old. Four years later the Nobel Prize for medicine was awarded to Francis Crick, James Watson, and Maurice Wilkins for their work on DNA. Nobels are given only to living persons, and no more than three winners can share each award. None of the men's Nobel lectures cite references to Franklin, and only Wilkins included her in the acknowledgments.

Although she was a strong experimentalist, Franklin favored the inductive approach to science and was critical of speculation. Thus she did not make great leaps of imagination; but through her keen observations and employment of very precise techniques, she was able to make crucial contributions to one of the great discoveries of the twentieth century and help lay the foundations for the science of structural molecular biology.

Notes

1. Aaron Klug, "Rosalind Franklin and the Discovery of the Structure of DNA," *Nature* 219 (Aug. 24, 1968): 808–10, 843–44.
2. Rosalind Franklin and R.G. Goslin, "Evidence for a 2-Chain Helix in Crystalline Structure of Sodium Deoxyribonucleate," *Nature* 172 (1953): 156–57.
3. Rosalind Franklin, "Crystallite Growth in Graphitizing and Nongraphitizing Carbons," *Proceedings of the Royal Society* 209A (1951): 154.

4. Anne Sayre, *Rosalind Franklin and DNA* (New York: Norton, 1975).
5. James Watson, *The Double Helix* (New York: New American Library, 1968).
6. Sharon Bertsch McGrayne, *Nobel Prize Women in Science: Their Lives, Struggles, and Momentous Discoveries* (Secaucus, N.J.: Carol Pub. Group, 1993).
7. Rosalind E. Franklin and A. Klug, "Order-Disorder Transitions in Structures Containing Helical Molecules," *Discussions of the Faraday Society* 25 (1958): 104–10.

Bibliography

Bernal, J.D. "Dr. Rosalind Franklin." *Nature* 182 (July 19, 1958): 154.
Jevons, Frederick Raphael. *Winner Take All: Case Study of the Double Helix.* Waurn Ponds, Vic.: Deakin University, 1987.
Judson, Horace Freeland. "Annals of Science: The Legend of Rosalind Franklin." *Science Digest* 94 (Jan. 1986): 56–59.
———. *The Eighth Day of Creation.* New York: Simon and Schuster, 1969.
Kass-Simon, G., Patricia Farnes, and Deborah Nash, eds. *Women of Science: Righting the Record.* Bloomington: Indiana University Press, 1990.
Klug, Aaron. "Rosalind Franklin and the Discovery of the Structure of DNA." *Nature* 219 (Aug. 24, 1968): 808–10, 843–44.
———. "Rosalind Franklin and the Double Helix." *Nature* 248 (Apr. 26, 1974): 787–88.
McGrayne, Sharon Bertsch. *Nobel Prize Women in Science: Their Lives, Struggles, and Momentous Discoveries.* Secaucus, N.J.: Carol Pub. Group, 1993.
Sayre, Anne. *Rosalind Franklin and DNA.* New York: Norton, 1975.

MARGARET SYLVIA

CHARLOTTE FRIEND

(1921–1987)

Microbiologist

Birth	March 11, 1921
1944	B.A., Hunter College
1946–66	Associate Member, Sloan-Kettering Institute
1950	Ph.D., Yale University
1952–66	Associate Professor of Microbiology, Sloan-Kettering
1954	Alfred Sloan Award
1957	Alfred Sloan Award