

Rosalind Franklin: The Woman Scientist of DNA

It is fifty years since Watson and Crick first proposed the structure of DNA in their paper in *Nature* in 1953. The same issue also carried the papers by Wilkins, Stokes and Wilson and by Franklin and Gosling. The Nobel Prize in Physiology or Medicine was awarded to Watson, Crick and Wilkins. Rosalind Franklin had died at the young age of 37 in 1958 of cancer. She was never awarded the Nobel Prize as it is not given posthumously. But it was Franklin's unpublished measurements of the crucial distances in the DNA molecule, provided by her colleague Wilkins, without her knowledge, to Watson and Crick, that enabled them to build a model of DNA. This fact came to light nearly ten years after the award of the Nobel Prize. In their Nobel Prize lecture neither Watson nor Crick thanked Franklin for making their discovery possible. To this day, Watson emphasizes the opinion that Rosalind, although a gifted experimentalist, could not properly interpret all of her own DNA data. However, the meticulous studies of the brilliant scientist, as Rosalind was described by her biographers, has led Lynne Alkine, Professor at California State University, to suggest that a meaningful gesture, given that it was Franklin's data that the Watson and Crick most directly used, would be for scientists to refer to the "Watson, Crick and Franklin Structure of DNA".

The first biography was written by her personal friend Anne Sayre in 1975 and the recent book *Rosalind Franklin: The dark lady of DNA* is by a brilliant biographer Brenda Maddox who has never known Franklin. Both these biographers refute the infamous nature of the personal description of her which was given by James Watson in his book *The Double Helix*. The celebrated

work, which she did with Desmond Bernal on RNA viruses like tobacco mosaic virus (TMV), which was a subject more challenging than DNA, was acknowledged by Aaron Klug in his 1982 Nobel Lecture. Klug was her closest collaborator and friend. Bernal wrote in the concluding part of Franklin's obituary note that as a scientist Franklin was distinguished by extreme clarity and perfection in everything she undertook to do. Her X-ray photographs are among the most beautiful of any substance ever taken. It was the famous X-ray diffraction photograph of B-DNA and the crystalline parameters she had laboriously calculated, given to Watson and Crick by Wilkins, that formed the significant basis for solution of the DNA structure.

Franklin was born on 25 July 1920 to Muriel Waley Franklin and merchant banker Ellis Franklin, both members of educated and socially respected Jewish families. The family was close-knit and prone to lively discussion and vigorous debates. Rosalind thus learnt to argue and to be determined about her views. She even argued with her assertive, conservative father. Rosalind expressed an early fascination for physics and chemistry at the academically rigorous St. Paul's Girls School in London and earned a Bachelor's degree in natural sciences with a speciality in physical chemistry. The degree was awarded at Newnham College, Cambridge, in 1941.

At the age of 21, Rosalind started her research on crystalline materials in support of an important wartime project. Coal was used in gas masks during World War II, and Franklin investigated why some kinds of coal are more impervious than other kinds to gas and water. This work earned her a PhD degree from Cambridge in 1945. As an

“expert on holes in coal” she was invited by J Mehring to work in his laboratory in Paris and it is here that she latched onto X-ray crystallography and used it to study distorted carbon crystals. Maddox describes Franklin in Paris as “a woman of the Left Bank – happy, beautiful, successful and valued by colleagues”. However, Maddox also adds that Franklin understood her capabilities and was forthright about speaking up, an unexpected and perhaps unwelcome trait for a female scientist. Watson in his book *The Double Helix*, portrays this difficult part of Franklin’s personality and gives the idea that Watson and Crick had to rescue DNA data from this “belligerent” woman who could not keep her emotions under control and who did not know how to interpret her own data. Key DNA participants vehemently protested these inaccuracies, but still the book was published. However, Maddox brings out a fact not generally known that *The Double Helix* was originally scheduled to be published by Harvard University Press. The outcry from eminent scientists and from Franklin’s family was so intense that Harvard’s board of overseers asked the Press to drop the book. Atheneum published it later.

Franklin’s success in Paris with X-ray crystallography landed her a fellowship at King’s College, London, in 1951, to study proteins in solution and in dehydrated forms. Before leaving Paris, she carefully designed the apparatus she would need. When she arrived at King’s College, the focus of the project changed from protein solutions to biological fibers, particularly DNA. Control of humidity became a serious issue because DNA fibers lengthen as they hydrate, and the motion blurs the photographs. Franklin was well versed with such problems through her work with crystalline forms of coal.

The move to King’s College was scientifically fruitful but the atmosphere in which Franklin labored was intensely hostile. The lab director, John Randall, informed Franklin by letter that only she and a graduate student Ray Gosling would be working on her project. However, Randall was already studying DNA fibers with Maurice Wilkins. Randall and Wilkins needed Franklin’s X-ray diffraction experience, but offered her only a three-year fellowship, with neither rank nor an academic appointment. Understandably, the laboratory relations between Franklin and Wilkins were uncomfortable. This could be the main reason for Watson and Crick routinely citing the more senior Wilkins before Franklin, and Wilkins repeating much of Franklin’s work. In addition, Wilkins and not Franklin, was nominated for membership in the Royal Society even though, at the time of his nomination, Franklin was famous for her TMV accomplishments. Even in the present day, women scientists the world over are familiar with such irreverence and injustice to their work and to themselves!

Under great stress of hostility from her colleagues in King’s College she produced her X-ray photographs and laborious calculations that suggested a helical structure with the phosphate groups on the outside. She discovered the B form of DNA and was the first to photograph it and to measure the spacing between the bases and the cylindrical repeat distance. She wanted to delay her final decision about the structure until she and Gosling were completely convinced by the data. But, as noted above, the data with the crucial photograph were passed on to Watson without the knowledge of Franklin. The three papers appeared in the 25th April issue of *Nature*. Franklin’s paper appeared to be merely confirming the results of the

paper by Watson and Crick though it was written one month earlier!

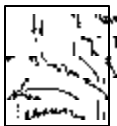
Franklin's tenure to the Medical Research Council at King's College ended in an unfortunate note. As a condition to agreeing to transfer her fellowship to Birkbeck, Randall made Franklin promise not to perform additional experiments on DNA or *even to think about DNA*. Not only this, she was forced to leave her diffraction photograph behind at King's and to leave the work of confirming DNA's structure to Wilkins. Personality conflicts and, added to them, her status as a woman scientist, were the major sources of Franklin's difficulties at King's College. Even to this day, as many women scientists will agree, a forthright and strong personality is tolerated in a man but not when demonstrated by women. She is then labeled as "belligerent", as Watson puts it in his book *The Double Helix*. His irreverence to Franklin did not allow him to see how much of her work

had influenced the DNA model he and Crick had proposed. As an effective device to avoid acknowledgment Watson promoted the idea of her inability to interpret her own data and that it is they who rescued the DNA data.

Franklin continued her brilliant scientific career at Birkbeck College, contributing to the understanding of the tobacco mosaic virus (TMV). So, it was the attitude of her male colleagues at King's College that denied her of her warm and affectionate personality traits and the glory for the intense impact her work had on understanding of DNA structure, which indeed should be referred to as "Watson, Crick & Franklin DNA structure".

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"As a scientist, Miss Franklin was distinguished by extreme clarity and perfection in every thing she undertook. Her photographs are among the most beautiful X-ray photographs of any substance ever taken".

J D Bernal

"Science and everyday life cannot and should not be separated. Science, for me, gives a partial explanation of life. In so far as it goes, it is based on fact, experience and experiment".

Rosalind Franklin
(in a letter to her father)