Rosalind Elsie Franklin (1920-1958) [1]

By: O'Connell, Lindsey Keywords: Watson-Crick model [2] DNA structure [3]

Rosalind Elsie Franklin worked with X-ray crystallography at King's College London, UK, and she helped determine the helical structure of DNA in the early 1950s. Franklin's research helped establish molecular genetics, a field that investigates how heredity works on the molecular level. The discovery of the structure of DNA also made future research possible into the molecular basis of embryonic development, genetic disorders, and gene manipulation.

Franklin was born in London on 25 July 1920 to Muriel Waley Franklin and Ellis Franklin. Rosalind's father followed the family tradition into a banking career, and both of her parents were involved in philanthropic and public service activities. Franklin was the second child of five and the oldest girl. According to Anne Sayre, Franklin's friend and biographer, Franklin's parents pushed all of their children toward self-expression and self-discovery. Franklin attended St. Paul's Girls school in London and studied science. At the age of fifteen Franklin decided to become a scientist. Brenda Maddox, another of Franklin's biographers, believes the decision surprised Franklin's family members because they did not expect their daughters to enter paid professions.

In 1938 Franklin attended Newnham College, the women's school at the University of Cambridge, England and she graduated in 1941 with a second-class degree in physical chemistry. For graduate studies, she stayed at Cambridge University [4] in 1941 for a year and worked with Ronald George Wreyford Norrish. Franklin left Cambridge in 1942 and finished her graduate thesis while working during the war at the British Coal Utilization Research Association (CURA) in South London. Franklin's CURA work consisted of researching the physical structure of coal and carbon. From 1942 to 1946, Franklin published five papers on her CURA research. Her research helped companies understand how to burn coal more efficiently and why some coal and carbon turns to graphite when heated. In 1945 Franklin earned her PhD from Cambridge University [4] in physical chemistry based on her work at CURA.

In 1947 Franklin moved to Paris, France and worked with Jacques Méring at*Laboratoire Central des Services Chimiques de l'Etat* (Central Laboratory of the Chemical Services of the State). In Paris, Méring taught Franklin how to use X-ray crystallography. In X-ray crystallography, crystallographers shoot X-rays at crystalline structures. The atoms within the crystal diffract some of the X-rays in specific patterns, which the crystallographers capture on film. By measuring the angles and intensities of the patterns, the researchers are able to create a three-dimensional picture of the crystalline structure. Franklin mastered the technique by studying the crystalline structure of coal.

In 1951 Franklin accepted a Turner-Newall Research Fellowship to work at the new X-ray crystallography center at King's College associated with the University of London. John Randall, the head of the laboratory where Franklin worked, asked Franklin to supervise Raymond Gosling, a graduate student, and to use her knowledge of X-ray crystallography to uncover the structure of DNA. Before Franklin arrived to work with them, Gosling had used X-ray crystallography with Maurice Wilkins at King's College, and they had produced unclear pictures of DNA. Franklin developed a method of arranging the chromosomes to produce clearer pictures. To distinguish between two structures of DNA, named structure A and structure B, Franklin used variations in humidity by manipulating salt solutions. Franklin's research revealed that Gosling and Wilkins's pictures were blurred images of both structure A and B.

Franklin found that structure A appeared at low humidity and had a lined, crystalline appearance. Structure B appeared at higher humidity and had a distinct cross pattern, indicative of a helical shape. Franklin initially thought DNA was shaped as a helix, as seen in structure B, but she had difficulty reconciling that with the fibrous appearance of structure A. Franklin wanted proof for her helical theory, but the more Franklin studied structure A, the less convinced she was that structure A was helical like structure B. This interpretation led Franklin away from the double helical structure of DNA later described by James Watson [5] and Francis Crick [6] at Cambridge University [4].

Biographers Sayre and Maddox write that when she took the DNA project at King's College, Franklin assumed that she would lead the effort, while Wilkins assumed that she was hired to help his team. From the beginning of Franklin's employment, the two scientists quarreled. Wilkins often complained of Franklin to two of his friends at Cambridge University [4], James Watson [5] and Francis Crick [6]. At the time, Watson and Crick were attempting to discover the structure of DNA by building and analyzing large-scale models.

In May of 1952 Franklin and Gosling produced a clear picture of structure B, but they turned the photograph over to Wilkins, as he was studying structure B. In 1953 Wilkins showed Franklin's structure B photograph to Watson as evidence of the helical nature of DNA. Watson saw that two phosphate backbones run in opposite directions on the outside and constitute a backbone of the helix in DNA. The Watson-Crick model included the fact that the purine and pyrimidine bases which connect the two phosphate chains through hydrogen-bonding bind to each other in specific ways. The four bases, adenine and guanine

(purines), and thymine and cytosine (pyrimidines) have molecular positions (tautomeric forms) that, when normal, only allow adenine to pair with thymine and guanine with cytosine.

When Watson and Crick submitted their findings for publication on 6 March 1953, Franklin was close to discovering the structure of DNA, and she used her work to support the Watson-Crick model. Wilkins published a separate article that further supported Watson and Crick's model. All three articles were published together in *Nature* on 25 April 1953. A sentence at the end of the Watson and Crick article states that they were influenced by Wilkins and Franklin's work.

Franklin's *Nature* article discusses how her work aligned with Watson and Crick's conclusions. Franklin mentions the reversibility between structure A and structure B with the change in humidity. Franklin also states that higher humidity allows the molecules to assume their lowest energy conformation, making it probable that structure B is the natural form of DNA. Franklin describes a formula used to decipher the data in the X-ray crystallography photographs and how that formula indicates that two phosphate backbones occupy the outer edges of the helical structure. Franklin asserts that, based upon her research about chemical properties, the phosphate groups are on the outside and the bases are on the inside of the helical structure. Franklin does not fully endorse the Watson and Crick model, but instead says the data does not disprove their model.

In January 1953 Franklin transferred from King's College to Birkbeck College in the University of London. While Franklin was able to lead her own team of researchers, administrators at King's College intimated to Franklin that she could only keep her fellowship if she ceased to work on DNA. With this requirement, Franklin began work on the molecular structure of viruses and the tobacco mosaic virus (TMV) [7], eventually publishing seventeen articles in five years. During Franklin's term at Birkbeck, her team consisted of Aaron Klug, Kenneth C. Holmes, and John T. Finch. Franklin and her team uncovered the single-strand, helical structure of RNA built into the hollow form of TMV.

In 1956 doctors diagnosed Franklin with ovarian cancer. Franklin continued her work intermittently between chemotherapy and surgical treatment. In 1957 the Brussels World's Fair committee asked Franklin to create virus molecule models to feature prominently in the virus exhibition at the fair. The Royal Society of London[8] and the Royal Institution of Great Britain also asked Franklin to contribute exhibits on her work. Franklin began to study poliovirus in October 1957 and continued working on both polio and TMV until she checked into a London hospital just before she died on 16 April 1958.

Four years after Franklin's death, Watson, Crick, and Wilkins received theNobel Prize in Physiology or Medicine[9] for their work with DNA. Only Crick mentioned Franklin's contributions in his Nobel Prize speech. As a rule, Nobel Prizes are not awarded posthumously, but many people later contended that had Franklin been alive, she also would have been awarded a Nobel Prize.

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