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# Profiles on the Feminine Burst into Science

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## *Abstract*

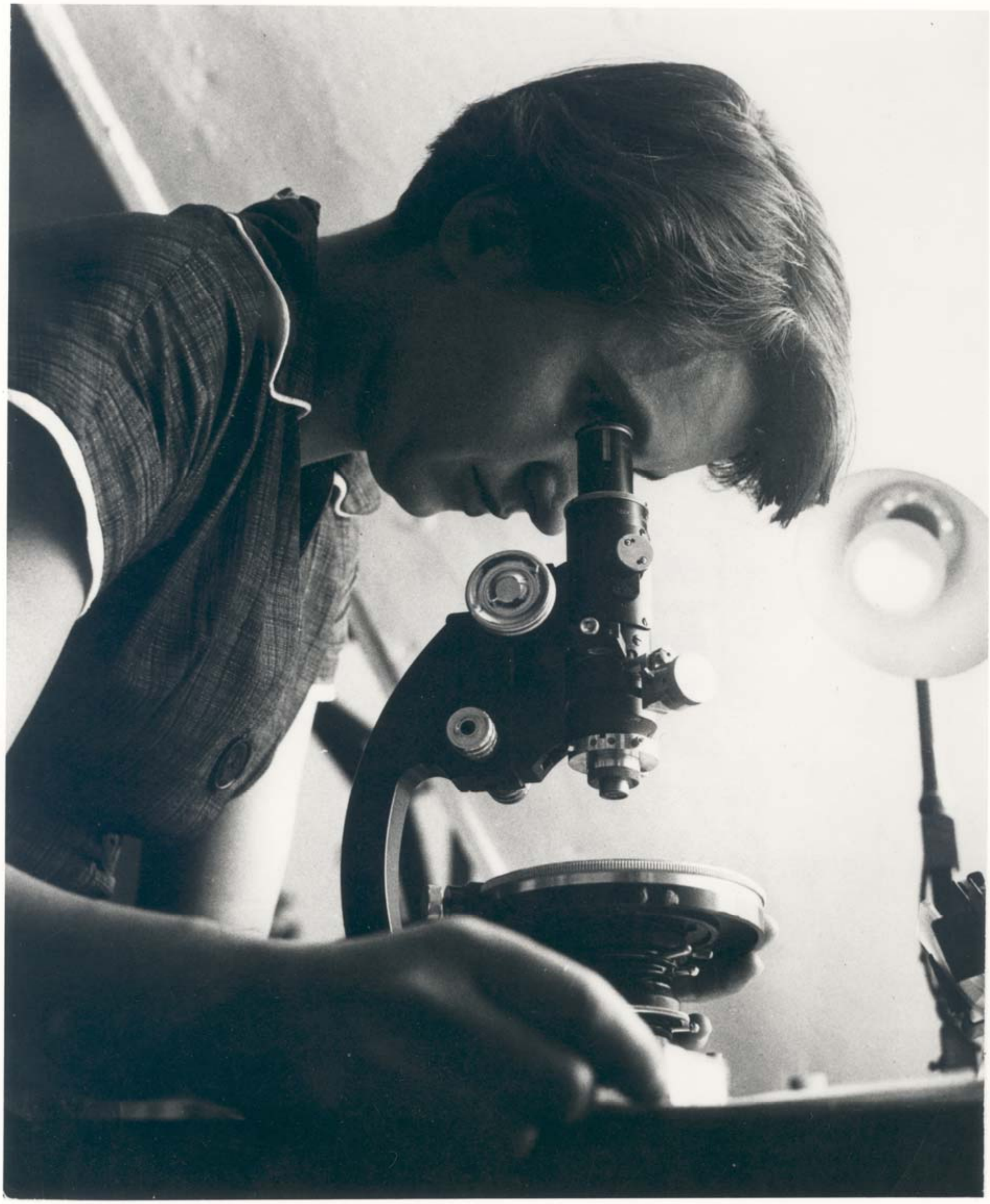
Both Rosalind Franklin and Barbara McClintock made significant contributions to the science during the 20th Century. This article focuses on the comparisons and contrasts between the two. These observations help describe these women's impact on sexual segregation in science. Both women did most of their research in a time when there was little acceptance for females in academia. Franklin played an important role in the discovery of the structure of DNA, taking the now famous photo of the "wet form" of DNA using X-ray crystallography. She was shunned from credit for her involvement largely due to her gender. McClintock was the first to identify and label the ten maize chromosomes as well as discover the mobile ability of some genes: a theory coined transposition. Though she would eventually receive a Nobel Prize in Physiology & Medicine, she was long denied professorships at universities solely based on her gender. Each woman had an individual methodology that directly led to her success as a research scientist. Similar family lives and upbringings led to parallels in the women's character. Overall, these comparisons profile the feminist rise in science as well as the women that led it.

## Profiles on the Feminine Burst into Science

Rosalind Franklin's name was made famous due to her part in the race to discover the structure of DNA. The discovery of transposable elements in genetics catapulted Barbara McClintock to her world-wide recognition of a Nobel Prize. These two women were also both heroes in the war to end sexism in science. Unknown to some, these two achieved biologists from the twentieth century shared more than their common interests and talents. What can be learned about sociality in science as well as feminism in society from McClintock, Franklin, and the comparison of the two?

Both women carried out their best-known experiments during the 1950's, a time when little if any women's liberation was taking place. Women were offered few degree programs and even fewer graduate programs at universities. Obvious gender segregation appeared within the universities themselves, where female academics were usually only permitted to become instructors or assistant professors regardless of education level. Both McClintock and Franklin ably managed this segregation though it was a challenge for each to overcome.

## Rosalind Franklin



Rosalind Franklin, X-Ray Crystallographer, 1920-1958
Courtesy National Library of Medicine <http://profiles.nlm.nih.gov/KR/>

When Rosalind Franklin was young, her parents found her, “practical and unsentimental, literal-minded and not imaginative” (McGravne 307). These traits would characterize her throughout her life and career, for the most part. Being “unsentimental” perhaps was the result of other seeing to her ability to objectively analyze data, as did being “literal-minded.”

Rosalind was born on 20 July 1920 in Kensington, London, U.K. to a wealthy Jewish banking family as the second of what would be five children. Her family unit was very incorporative as a group, with the children being active participants in family decisions and conversations. As she matured she preferred to “make” things, rather than play “pretend games” (McGravne 307). She actively enjoyed sewing and carpentry. When Rosalind was very young, she suffered a major infection which required rest, naps, and mild limitations on activity to be healed (Sayre 39). During this time, she resented the fact that limitations were placed on her and not her brothers, which led to morphed ideas of a disadvantage to her because of her gender. She attended St. Paul’s Girls School in London, an institution with a strict regimen and higher standards (Sayre 41). Rosalind later referred to her youth as a period made tense by her need to struggle for minimal recognition (Sayre 41).

In 1938, not many women professionals ended up as active social participants, which troubled Rosalind’s father, Ellis Franklin. Rosalind had her sights set on attending Cambridge University, but this conflicted with her father’s views. Ellis was doubtful of the utility of professional education for girls; after all, women scientists had limited prospects in the scientific community (Sayre 42). However, Rosalind did enter Newnham College at Cambridge as a chemistry major in the fall of 1938. At that time, Cambridge only awarded women “titular” degrees, which were considered to be inferior to men’s degrees. In a letter home, she commented that one of her chemistry lecturers was “good, though female” (Maddox 48). She earned a Bachelor’s Degree in 1941, a term early, after leaving a good record of work.

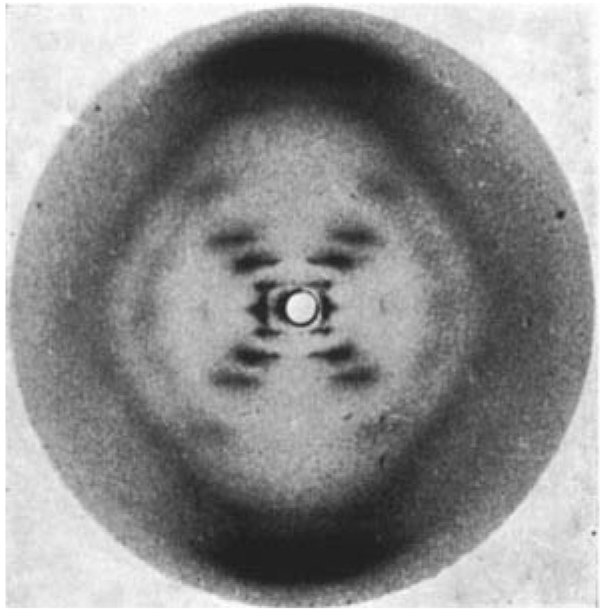
Franklin immediately began her graduate work at Cambridge under the supervision of physical chemist Robert Norrish at the Cavendish Laboratory. Her research was focused on coal, and eventually provided a means for coals and charcoals to be used more efficiently. This was especially important in England, where air pollution had begun to become a major concern. She published five papers between the ages of 22 and 26 on coals and carbon that are still referenced today. Her work on coal earned her a doctorate from Cambridge in 1945 (McGarvne 309).

With a newly earned doctoral degree, Franklin relocated to France to work with Jacques Mering at the *Laboratoire central des services chimiques de l'État* in Paris. She adored her new friends and the culture in France; she also noticed a different social scene there when it came to gender. There were not many sexist ideas, in fact, the war of the sexes scarcely existed (Sayre 71). It was in Paris that she adopted a socialist view on politics and began to resent her parents’ lavish lifestyle (McGravne 311).

In the lab Franklin took up a new technique: crystallography. X-ray crystallography uses a beam of X-rays passed through a crystal, where the beam is scattered in such a way as to record on film a visible pattern: the x-ray diffraction pattern. Franklin pioneered the use of X-ray diffraction to study disorganized and complicated matter, such as that in DNA (McGarvne 310). As Franklin was perfecting her technique in crystallography, John Randall was assembling a group of physicists and chemists at

King's College at the University of London to study living cells. Franklin's ability in studying complex substances made her a good candidate for this new group that was developing interest in the structure of DNA. She was offered and accepted a position at King's in 1950, and was obligated to leave her newfound friends in Paris to return to London.

The day that Rosalind arrived at King's, Dr. Maurice Wilkins was away on business. Franklin was to be Wilkins' colleague in the lab work on DNA, but this was unbeknownst to him. When he returned to King's, he assumed Franklin was to be his assistant; this primary misunderstanding led to all-out hostility between Wilkins and Franklin, who demanded full credit for her own work. The animosity has been noted as one of the greatest personal quarrels in the history of science (Judson 101). Regardless of her situation with Wilkins, Rosalind developed a positive relationship with graduate student Raymond Gosling. She trained him in crystallographical techniques, and he was eventually able to help her analyze microbiological diffractions. In the lab, Franklin and Gosling's findings were stored separately from Wilkins' findings because Franklin was highly protective of her intellectual copyright over the work.



“Photo 51” Taken by R. Franklin, May 1952. Courtesy Biophemera.com

Through her analysis of diffraction patterns, she discovered that there was an A form (dry form) and B form (wet form) of DNA.  At first, she focused her studies on the wet form, eventually taking the picture portraying the helical form of the B form of DNA in May 1952 (Glassman).  This photo would later inspire James Watson and confirm his belief that DNA was helical in structure, with the phosphate backbone on the outside. After her studies of the B form, Rosalind found more promise in studies of the A form, and adjusted her subjects of analysis.  She collected mounds and mounds of data from her work over nearly three years at King’s, but refused to make conclusions until she had had sufficient time to analyze all of the results.  Had she analyzed her data and calculated results as she proceeded, she may have beat Watson and Crick in the race to discover the helical structure of DNA (Kass-Simons 237).  Aaron Klug, a close personal friend of Rosalind’s, commented on the posthumous collection of her lab notebooks: “It is rather heartbreaking to look at these notebooks and see how close she had come to the solution by herself" (McGravne 323)

After dramatic situations unfolded during the race to the discovery of DNA structure, Rosalind felt tired at King's College. She highly disliked the gender-based segregation there, as she was unable to lunch or even collaborate with her male colleagues. She decided to take a position at Birkbeck College in London, and was forced to surrender all of her data on DNA upon leaving King's. This was fine in her sight; she wanted to "quit thinking about DNA entirely" (Sayre 169). She made the move in March of 1953, and her work prospered at Birkbeck; she took up viruses (TMV specifically) as her subject of research. In her first five years there, she published 17 articles on viruses.

Franklin fell ill 1955 and in the autumn of 1956 found that she had ovarian cancer. She told few people of her illness, and tried to go about life as normal. In fact, she still enjoyed tennis and climbing during a ten-month remission of her cancer (McGarvne 327). She asked for no sympathy from her friends ("Rosalind" 1). Rosalind encountered an untimely death at the age of 37 on 16 April 1958 in Chelsea, London.

Franklin's tenacity and focus drove her to become an accomplished crystallographer. Unfortunately, this journey presented conflicts such as segregation in the workplace and general under-appreciation. Another hero of feminism in science encountered similar conflicts in her early career: Barbara McClintock.

## Barbara McClintock

Barbara McClintock, Maize Genetics Pioneer, 1902-1992
Courtesy National Library of Medicine < http://profiles.nlm.nih.gov/LL/B/B/Q/Q/_/llbbqq.jpg>

From her childhood, McClintock faced the issue of sexism. She was born on 16 June 1902 in Hartford, Connecticut, as the youngest of three sisters to Thomas Henry McClintock and Sara Handy McClintock. Sara Handy desperately wanted a son (McGravne 147). Barbara always had a stressed relationship with her mother, who seemed to not forgive her for being born a girl. Sara McClintock's resentment against Barbara would continue to show throughout her early life, pushing Barbara to live with her aunt and uncle in Massachusetts between the ages of three and five. She had a good relationship with her father, a physician and great patron of education. When Barbara was in grade school, her father let her stay home from school when she decided her teacher was "emotionally ugly" (McGravne 148). Barbara wore boys' clothes when she was young by her own decision and with the acquiescence of her parents (McMurray 1345).

Barbara attended Erasmus Hall High School in Brooklyn. Upon graduating, she hoped to attend Cornell University. Barbara's mother was opposed to her daughters becoming professionals, and had already convinced one of her older daughters to a reject a scholarship for college (McGravne 148). Barbara eventually won the battle, with her father's support, and became the first of her siblings to attend college. She enrolled in Cornell's College of Agriculture in the fall of 1919. While at Cornell, McClintock became "a modern woman who smoked, bobbed her hair, and wore golf knickers for field work" (McGravne 149). She also experienced new social interactions, becoming good friends with many Jewish girls. She soon took up Yiddish, and refused to join a sorority because it didn't accept Jewish members (McMurray 1346).

She earned a B.Sc. in Botany in 1923, and entered a graduate program in cytology at Cornell. Her work as a graduate student revolved around maize genetics, though she could not earn a degree in genetics because women were not allowed to do so there; thus, she chose to study cytology with a minor in genetics. Barbara was incredibly efficient in the lab, with a professor commenting that she was capable of doing in three days what he hadn't done in years (Miller 1). During her graduate career she carefully identified and labeled each of maize's ten chromosomes, giving maize geneticists the opportunity to positively identify chromosomes in communication with one another. She followed up with post-doctoral work at Cornell as a botany instructor. During this time she published a paper with graduate student Harriet Creighton proving that a correlation existed between heredity and chromosomal crossover through a landmark study (McMurray

1346). This paper has since been referred to as “one of the greatest experiments of modern biology” (McGravne 156).

McClintock was offered a post-doc fellowship from the California Institute of Technology as well as one from The University of Missouri – Columbia. Between the years of 1931 and 1936, she spent time in labs at both of those establishments as well as at Cornell. She became the first female post-doc fellow to work at a men’s school at Cal Tech during this time (McGarvne 158).

In 1936, McClintock was offered a position as an assistant professor at the University of Missouri at the insistence of Lewis Stadler. She relocated to the “Show-Me State” and began to study the effects of X-ray exposure on cytogenetics. She discovered that when corn pollen is exposed to X-rays and therefore mutated, the chromosomes break apart and fuse back together. She called this occurrence the “breakage-fusion bridge cycle”. Though her work progressed during her stay at Missouri, she often felt underappreciated. She was never granted a full time position at the university, meaning she was excluded from faculty meetings. No woman had a full time appointment in the Botany Department at that time, and it didn’t appear that Barbara would be the first.

She spent the summer of 1941 at the Cold Spring Harbor Laboratory on Long Island, which was run by the Department of Genetics at the Carnegie Institution of Washington. Cold Spring Harbor was McClintock’s kind of place: everyone wore blue jeans, worked seventy to eighty hours a week, and loved biological research (McGravne 163). She was offered and accepted a research appointment there in December of 1941.

Once at Cold Spring Harbor, McClintock’s work progressed as she continued to study the breakage-fusion-bridge cycle. In 1944, she was elected to the National

Academy of Sciences and was only the third woman to have joined in its history[1]. That same year, she was elected president of the Genetics Society of America as the first woman to hold that post. During the summer of 1944, she began work on what would become the theory of transposition. She had identified two interacting gene loci, naming them the Dissociation (Ds) site and the Activator (Ac) site. She found the Ds site to be located on chromosome 9 in *Zea mays*. She also found a dominant factor (the Ac) that was always present when the Ds locus underwent breakage. The important part of this experiment was yet to come: McClintock discovered that the chromosome-breaking Ds locus could "change its position in the chromosome', or transpose it (Fedoroff 273). She had observed for the first time that genes did not necessarily occupy fixed positions on chromosomes. As a result of transposition, plant offspring could have an unexpected pattern of heredity due to a specific gene code that other offspring did not have. Barbara's discovery went against the then conventional genetic wisdom that genes were the stable components chromosomes.

McClintock's first publication on transposition was released in 1950, and was not received well (McMurray 1347). She presented her paper titled "Chromosome Organization and Genetic Expression" at the Cold Spring Harbor Symposium of 1951, and felt a general sense of hostility from the audience (Federoff 273). A fellow biologist who attended her talk later referred to her as just "An old bag who's been hanging around Cold Spring Harbor for years" (McGravne 168). Regardless of the acceptance by her peers, Barbara continued work on transposable genetic elements, and soon lost contact with many of her peers because her work in maize genetics was simply more advanced

[1] Florence Rena Sabin (1871-1953) was the first woman elected to the National Academy of Sciences in 1925. .

than anyone else's at the time (Federoff 273). She had come to command intellectual respect from her peers with her advanced cytogenetic work.

Barbara had taken a view on science based on intuition. In *A Feeling for the Organism*, Evelyn Keller claims that McClintock saw "further and deeper into the mysteries of genetics than her colleagues." Keller gave the reason that her methodological emphasis on intuition, feeling, and connect and "feeling for the organism" led her to practice more efficient science, what Keller called "feminist science". Barbara built an intense relationship with her plants, to the point where there was almost a spiritual connection (McMurray 1347).

McClintock wearing Groucho Glasses
Courtesy American Philosophical Society < http://profiles.nlm.nih.gov/LL/B/B/P/Y/_/llbbpy.jpg >

Barbara stayed at Cold Spring Harbor for the remainder of her life, waiting for the rest of the maize geneticists to catch up to her work. Eventually around 1970, with a better understanding of the molecular mechanisms of heredity, they did. She began to receive one award after another, but disliked the publicity and limelight that came with them. She was awarded the Nobel Prize for Physiology or Medicine in 1983 as a sole recipient, thirty-five years after her original publication on transposition. The rest of the genetic world had caught up to her and realized the contributions she made. Even in her senior years, Barbara continued to be independent and able-minded; she changed the tires on her car by herself until she was 80 years old (McGravne 164). She remained an independent researcher at Cold Spring Harbor until her death on 2 September 1992 at age 90 in Huntingdon, New York.


Commemorative Stamp, Released 2005
Image Courtesy of USPS <http://www.usps.com>

## Conclusions: A World of Feminist Contrasts

One of the most notable differences between Franklin and McClintock was the contrast of their separate methodologies. As noted before, McClintock took more of a theorists' view on science, while using intuition and feeling to discover new things about maize genetics. As a contrast, Franklin demanded proofs and facts to confirm any analysis she made. Anne Sayre referred to Franklin as one of the world's greatest empirical scientists. It could be reasoned that Franklin's demand for detail may have hindered her from figuratively seeing the structure of DNA, as Watson and Crick successfully did. Surely, it is most interesting to note each woman's success despite their different methodologies. Each of them practiced science according to their inner inclinations, and used these unique methods to achieve successful results. One methodology, or one woman, cannot be placed above the other in this respect (Richards 697-720).

As far as feminism appearing in their character, Franklin was beyond McClintock, though neither woman should be thought of as a soft person. Nether of them ever wore make-up; yet, Franklin had a knack for fashion after her fist visit to France, and began altering her own clothes due to the fashion of the moment (McGravne 308). She moved with an elegant, neat swiftness (Sayre 25). Her well-to-do family in London demanded that she be socially accepted. McClintock's parents were more liberal in thought; when Barbara was a girl, her parents allowed her to wear boys' clothes, because that was what she desired. During her years as a scientist, she was usually seen wearing knickers with her hair bobbed smoking a cigarette. This approachable appearance made relationships with her peers very open.

Neither Franklin nor McClintock viewed the idea of marriage optimistically. In the time of their research, female staff at universities were expected to forfeit their fellowships or paid positions upon becoming engaged. An revealing incident occurred while McClintock was working at the University of Missouri-Columbia. A woman with the same name announced her engagement in the local newspaper. The chairman of her department mistakenly threatened Barbara, "If you get married, you'll be fired"

(McGravne 144). Barbara had little inclination to marry or start a family regardless, mostly because of her research position (McMurray 1346). When questioned about her single status, McClintock replied, "marriage would've been a disaster, men weren't strong enough, and I know I was a dominant person…I knew I'd become very intolerant, that I'd make their lives miserable" (McGravne 47). Franklin was just as opposed to having children as to being married; she believed that a mother's place was in the home, and as a professional she would not be able to provide this (Sayre 52).

Oddly enough, Franklin's Jewish faith is coincidental to the fact that McClintock surrounded herself with Jewish friends, and became very fond of the faith. Franklin overcame obstacles because of her gender and her ethnicity, yet remained true to family tradition (Maddox 61). McClintock sympathized with her Jewish friends who were not accepted into sororities by not joining one herself. McClintock also learned Yiddish. Both women had an independent personal view on religion, however. When Franklin first read the bible to find a reason for believing in God, she concluded: "Well, anyhow, how do you know He isn't a She?" (McGravne 307). McClintock was interested in eastern religions, and practiced methods to control her own body functions. This provided her with the ability to see what was going on in her mind long before she could prove it (McMurray 1348).

The family lives of these two women were similar. Both enjoyed a comfortable lifestyle when young and were born wealthy enough to never have to work. While both were encouraged by their fathers to think creatively and become individualistic, their relationships with their mothers were quite different. Franklin's mother as well as her aunts encouraged her to become an intellectual from an early age, though they would have preferred for her to work in voluntary organizations rather than in science. McClintock's mother was strongly opposed to women becoming professionals; she saw it as an end to a woman's social normality. As young girls, both enjoyed playing with boys: Franklin with her brothers, and McClintock with her neighbors. The fact that McClintock had only sisters until she was 8 years old may have molded her to become more boyish, behaving like the son that her parents loathed for.

Of all the traits that these women shared, one seems to have contributed most to progressivism in female science: tenacity. Any group trying to overcome segregation or under appreciation must posses such a characteristic. Fortunately for the aspiring female scientists of today, women before them have set the path to equality ablaze by focusing a sense of drive and patience on their research. Special gratitude should be extended to Ms. Rosalind Franklin and Ms. Barbara McClintock, without whose outstanding achievements both feminism and science as a whole may be set back to less informed state than they hold today.

# Timeline Comparison

| Barbara McClintock | Rosalind Franklin |
|---|---|
| 1902: Born, June 16 | |
| 1905-1907: Lives in MA with aunt and uncle | |
| 1919: Enrolls at Cornell | 1920: Born, July 20 |
| 1923: Earns Bachelor’s degree in Botany | |
| 1931: Awarded fellowships at Cal Tech and Missouri | |
| 1936: Accepts assistant professorship at Missouri | 1938: Enrolls at Cambridge (U.K.) |
| 1941: Accepts position at Cold Springs Harbor laboratory | 1941: Earns Bachelor’s degree; Enters graduate program |
| 1944: Admitted to the National Academy of Sciences | |
| 1944: Elected President of the Genetics Society of America | |
| | 1945: Earns PhD at Cambridge |
| | 1946: Relocates to France |
| | 1950: Accepts position at King’s College, London |
| 1951: Gives symposium at C.S.H. on transposition | |
| | 1952: (May) Takes now famous photo of the B form of DNA |
| | 1953: Moves to Birkbeck College |
| | 1955: (Fall) Falls Ill |
| | 1956: Discovered her cancer diagnosis |
| | 1958: Dies, April 16 |
| 1983: Awarded Nobel Prize for Medicine or Physiology | |
| 1992: Dies, September 2 | |

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