

Science

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Biography #1 – Barbara McClintock (1902 – 1992)



Barbara McClintock, 1902 – 1992.

In 1929, Barbara McClintock puzzled over a cob of multi-coloured corn, or maize. The pattern of colours in the kernels didn't make sense according to the accepted rules of genetics. But then, in a flash of insight, McClintock thought that she knew why. She grabbed a pen and the closest writing surface on hand. On a brown paper bag McClintock scrawled the ideas that led to two major papers and eventually a Nobel Prize.

Barbara McClintock was a tomboy. At birth, her parents named her Eleanor, but by the time four months had passed, they decided Eleanor was too soft a name for the little girl. They changed her name to Barbara because it sounded tougher. When Barbara was four years old, her father gave her boxing gloves.

The young tomboy ice-skated, rode a bicycle, and played baseball with the local boys. When her own baseball team was too embarrassed to let her play in an away game because she was a girl, she joined the other team as catcher and helped them win. Convention was never going to keep Barbara McClintock from what she knew she could do.

Barbara graduated from high school during World War I. Her father, a homeopathic physician, was with the army in France, working in the medical corps. Barbara wanted to attend Cornell University, but her mother refused to let her. Too much education, Mrs. McClintock felt, would drive away potential husbands. She had already made Barbara's older sister turn down a scholarship to Vassar. So Barbara took a job in an employment agency and spent her free time in the public library, studying.

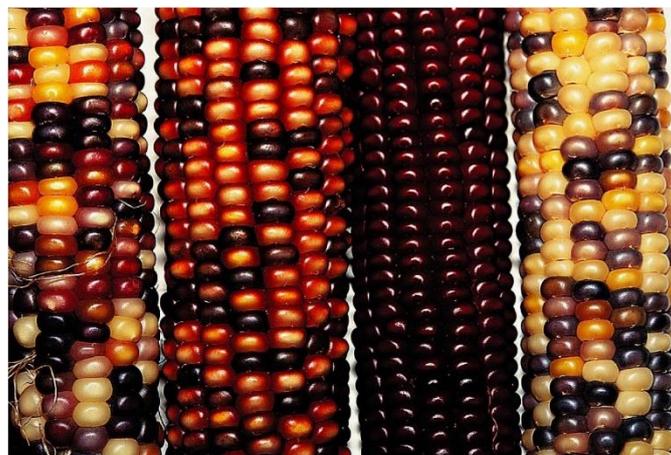
As soon as her father returned home, he took his daughter's side. Barbara enrolled in Cornell's free College of Agriculture, becoming the only one of her parent's four children to attend college.

Barbara thrived at Cornell. She became president of the freshmen women, and she played tenor banjo with a jazz band. She smoked, kept her hair very short, and wore golf knickers fastened just below the knee for her fieldwork. She learned Yiddish because her best friends were Jewish women. She took a course in genetics, which fascinated her, but since women were not allowed to major in genetics, she majored in botany instead.

When McClintock graduated from Cornell in 1923, she slipped easily into graduate studies. In the 1920s, perhaps because of the recent war, thirty to forty percent of graduate students in the United States were women. Women were well represented in biology, especially in botany. McClintock joined a Cornell group studying the genetics of maize.

Genetics is the study of how inherited traits are passed from parental organisms to their offspring. In the 1920s, the notion of a gene was an abstract concept with no physical model. An understanding of DNA's structure was three decades away. Chromosomes, however, had been observed in the nucleus of the cell, and they were known to determine hereditary traits. At Columbia University, the geneticist Thomas Hunt Morgan was studying fruit fly chromosomes. Morgan identified the fruit flies' four chromosome pairs under the microscope, and he "mapped" traits to chromosomes, showing that certain traits, like body colour or wing length, tended to be inherited together. These traits mapped onto the same chromosome.

To Barbara McClintock, maize provided a fascinating new model species for studying genetics. For one thing, the pattern of kernels on the multi-coloured cob was like a chart of its genes. Secondly, each maize plant produces both male and female flowers, so a plant can either be bred to itself or bred with a different specimen. Ordinarily, wind fertilises maize by blowing male pollen from the tassel at the top of one plant to the female flowers on the cobs of another plant. To control this promiscuous mating, researchers covered the ears of the maize with paper bags and transferred the pollen by hand.



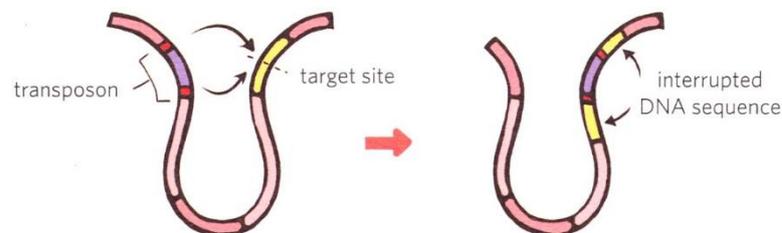
- Ears of corn (maize) showing different coloured kernels.

McClintock worked in the botany department staining and examining corn chromosomes under a microscope. No one had studied these chromosomes before. McClintock was able to map visible traits to chromosomes just as Morgan had done for fruit flies. She worked day and night, nurturing her corn through drought and flood and then spending long hours in the laboratory. By the time she received her Ph.D. at the age of twenty-five, she was already the leader of a group of young Cornell geneticists who remained friends and collaborators throughout their lives. Around the same time though, McClintock decided she would never marry. “Marriage would have been a disaster ... I knew I was a dominant person ... [men are] not decisive. They may be very sweet and gentle, and I knew that I’d become very intolerant and make their lives miserable.”

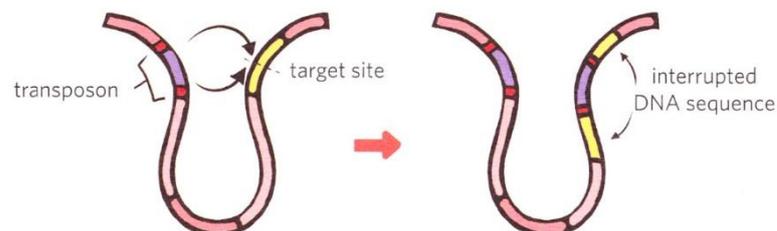
Immersing herself in her work, McClintock began a series of important papers in maize genetics. In 1929, she suggested a thesis topic to a graduate student named Harriet Creighton. They decided to investigate two physical traits – waxy kernels and purple kernels – that were inherited together on the ninth chromosome. McClintock wanted to show that sometimes chromosomes broke and mended themselves in ways that created new combinations of traits.

Carefully, the two women bred waxy, purple corn with non-waxy, non-purple corn. The next autumn, they harvested the ears of corn. Most had kernels that matched one of the two parent strains. But some ears were different. They had either purple kernels that were not waxy or waxy kernels that were not purple. When McClintock and Creighton examined the chromosomes of these odd kernels, they saw that the actual form of the ninth chromosome had changed, with lengths broken off and exchanged between chromosome pairs.

1. *Cut-and-paste mechanism*



2. *Copy-and-paste mechanism*



- Possible methods by which transposons cause genetic variation.

The discovery was huge. Thomas Hunt Morgan heard about it on a visit to Cornell, and he helped the two women publish their paper in August 1931. People called it one of the great experiments of biology, and more than one geneticist said the discovery merited a Nobel Prize.

But in 1931, despite her growing reputation, Barbara McClintock left Cornell. The faculty had made it clear that they would never dedicate a permanent faculty appointment to a woman. For the next five years, McClintock worked in a series of short-term fellowships. "I couldn't wait to get to the laboratory in the morning," she said, "and I just hated sleeping." She treasured the fellowships for the freedom they offered her.

During this time, McClintock began to study how X-rays increased the mutation rate in corn, as they did in fruit flies. She found that X-rays caused chromosomes to break. Sometimes the frayed end of one chromosome found the frayed end of a different chromosome, and the two chromosomes healed onto each other, creating new combinations of traits.

In 1931, McClintock became the first woman to do a postdoctoral fellowship at Caltech, although as a woman she was not allowed inside the faculty club. While at Caltech, she discovered the *nucleolar organiser* region of the chromosome. Two years later, in 1933, McClintock used a Guggenheim fellowship to work for six months in Germany. Politics, thyroid problems, loneliness and the persecution of the Jews drove her home early.

In 1936, at the age of thirty-four, McClintock finally obtained a faculty position at the University of Missouri. But she was only an assistant professor, and her position was insecure. As a lecturer, she spoke so fast she was hard for some students to follow. As a research mentor, she was tough and demanding. "Everyone was scared of her," said one student, Helen Crouse. "You had to have a pretty sturdy constitution to survive."

By 1941, McClintock realised that the university was a dead-end for her. Fellow faculty excluded her from department meetings, and administrators were reluctant to accommodate her research. Finally, she asked Missouri's dean if she would ever get promoted to a permanent position. He told her no. If her department chair ever left, the dean added, she would probably be fired. Furious, McClintock took an immediate leave of absence, determined never to return to a university.

Still, she needed a place to plant her corn, and she asked her old friend Marcus Rhoades for help. He found her a temporary post at Cold Spring Harbour, a centre for the study of evolution on rural Long Island. Within a year, the Carnegie Institution gave Barbara McClintock a permanent research position there. Now she could do research surrounded by geneticists and without the distraction of teaching. She wore blue jeans and worked seventy to eighty hours per week. And she kept planting corn.

In 1945, McClintock discovered that when corn chromosomes had broken and reattached several times, one cell would completely lose a chunk of genetic material that then showed up in another cell. She discovered that chromosomes include switches that turn genes on and off and activators that can make the switch jump around the chromosome. Nowadays, the moving chromosome parts are called *transposons* or *jumping genes*.

Geneticists respected the care and thoroughness of McClintock's work, but scientists in the emerging field of molecular biology did not take her ideas seriously. "I don't want to hear a thing

about what you're doing. It may be interesting, but I understand it's kind of mad," one scientist told her. McClintock's maize genetics was too complicated. Biologists wanted their genes stable, like beads on a chromosome necklace.

Disappointed that so few scientists understood her research, McClintock decided to spend less time reporting it publicly. She nevertheless kept recording and analysing her results, which she summarised in short notices for the Carnegie Institution year after year. The media portrayed her as something of a recluse, someone difficult and eccentric. But McClintock enjoyed close friendships. She ran, swam, played tennis, and enjoyed long nature walks on Long Island.

Beginning in the late 1950s, the National Science Foundation and Rockefeller Foundation sponsored McClintock on regular trips to South America to study the origins and evolutionary history of maize. She worked with, trained and advised young scientists from all over the continent, and made a fundamental contribution to the new field of paleobotany.

By the 1960s, molecular biology began to catch-up with McClintock. Her work made its way into genetics classes. Scientists discovered transposons in bacteria and even in humans. From the 1960s on, McClintock began accumulating prestigious research awards, including the Albert Lasker Prize, the Wolf Prize, and a MacArthur Fellowship, all during one year, 1980 – 1981. The awards made her uncomfortable, "I don't like publicity at all," she said.

Then, in 1983, at the age of eighty-one, Barbara McClintock heard on the radio that she had won the Nobel Prize for Medicine or Physiology. Marcus Rhodes, in nominating McClintock for the Prize, wrote of her "surpassingly beautiful investigations." Rhoades went on to say,

"Without technical help of any kind, she has by virtue of her boundless energy, her complete devotion to science, her originality and ingenuity, and her quick and high intelligence made a series of significant discoveries unparalleled in the history of cytogenetics."

The Nobel Prize, awarded "for her discovery of mobile genetic elements," demonstrated that the world finally understood how McClintock's studies in corn clarified underlying principles of genetics that held true throughout the plant and animal kingdoms.

Although she had officially retired from the Carnegie Institute at age sixty-five, Barbara McClintock continued her research at Cold Spring Harbour throughout her eighties. She stopped running for exercise and took up aerobics instead. She cut the length of her workday down to eight or nine hours. Some people say that she mellowed a bit and became less impatient. She advocated for women in science and kept up her correspondence with colleagues. Still in love with science, she kept reading, travelling, and planning experiments until her death in 1992 at the age of ninety. Her life had been one of incredible focus and discipline, and it had paid off in remarkable discoveries about how genetics and evolution lead to great diversity. Above all, she told interviewers, it had been "a very, very satisfying and interesting life."

• Noyce, P. (2015). *Magnificent Minds* (pp. 101-107). Boston, MA: Tumble Home Learning, Inc.