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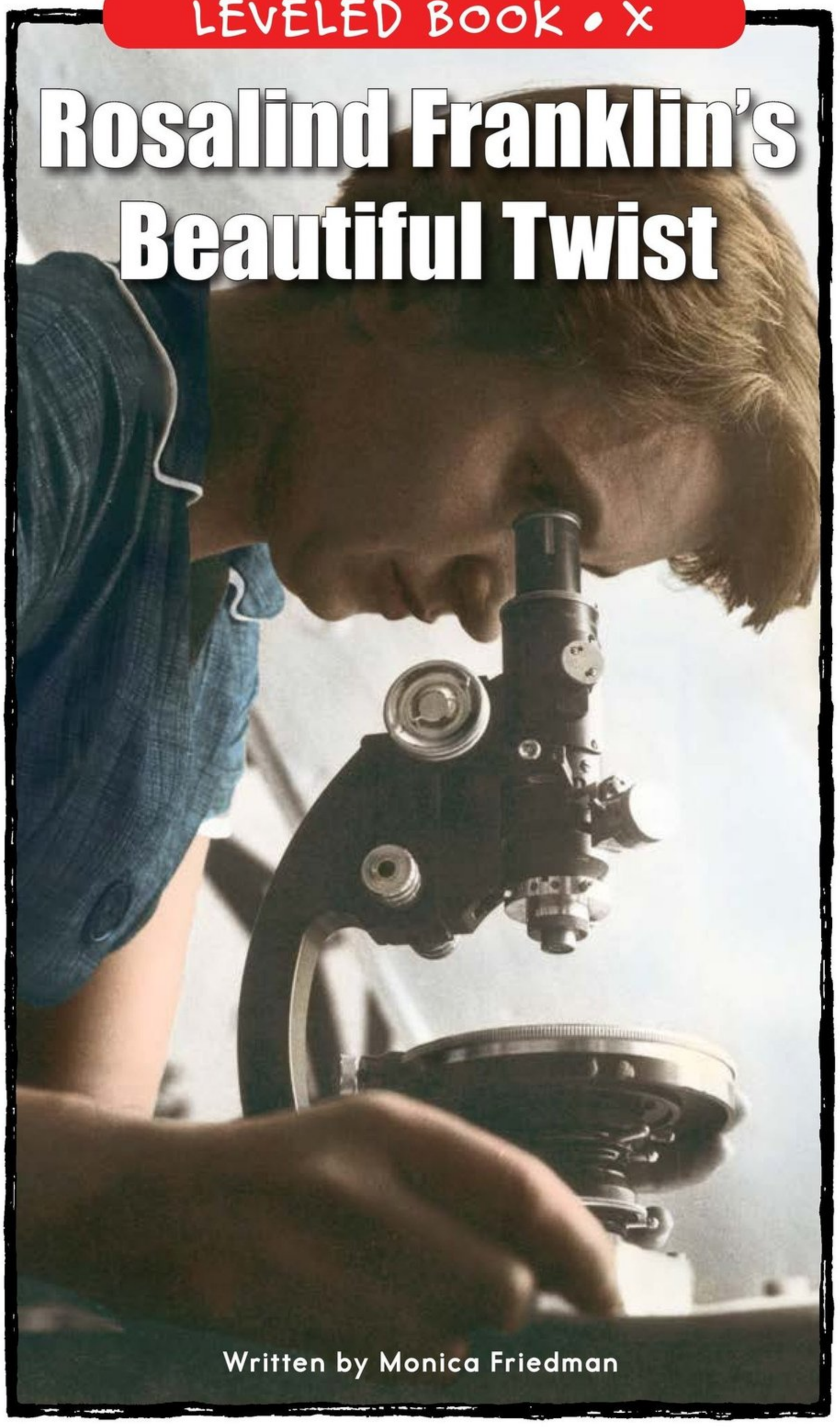
Rosalind Franklin's Beautiful Twist



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The double-helix structure of DNA

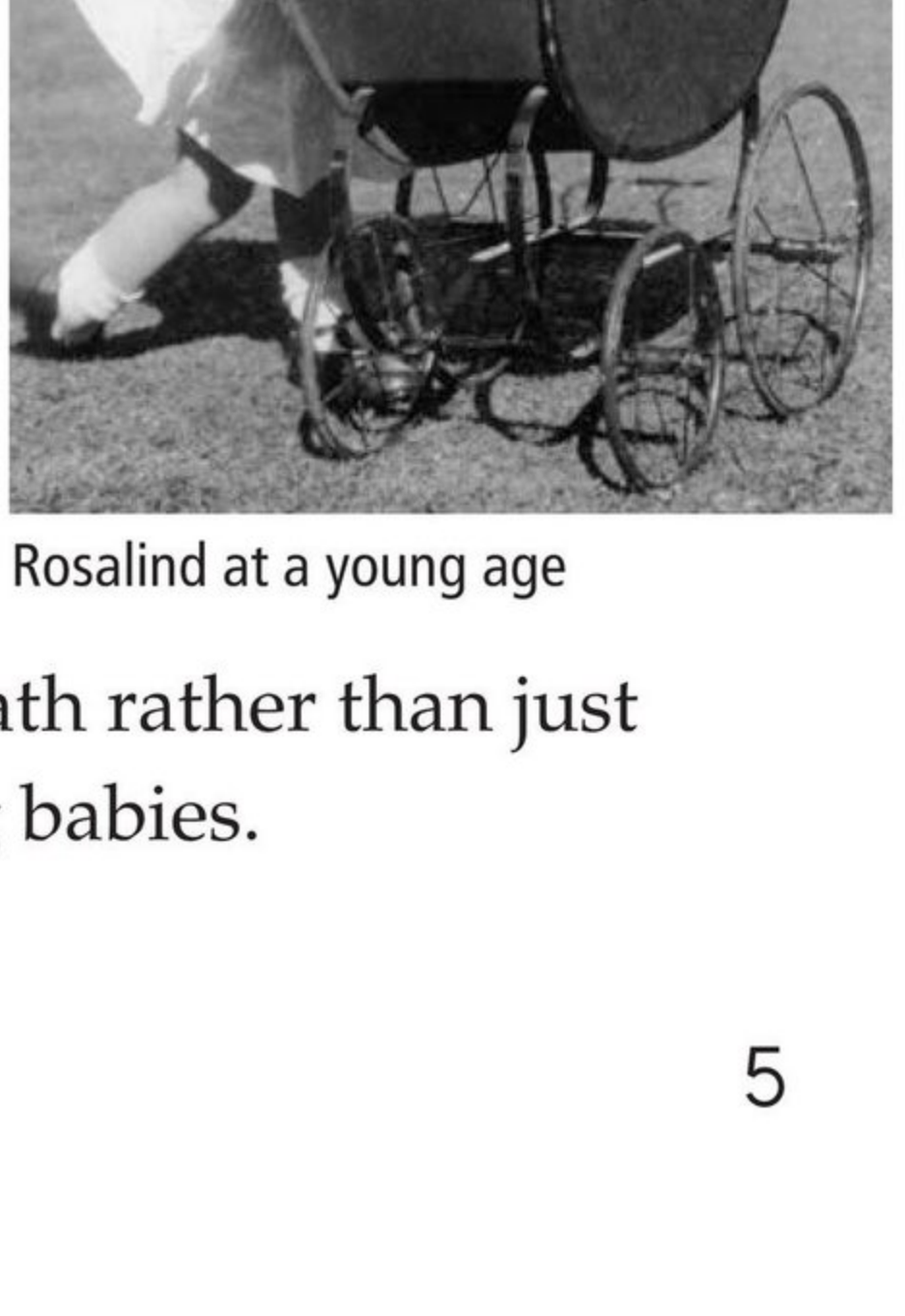
The Beautiful Twist

Have you ever seen this elegant shape? It's a **double helix**, and even if you don't recognize it, it's an important part of you. The double helix is the shape of **DNA**, which is like a blueprint contained within the **cells** of every living thing. It's a plan for how to build you! DNA in the cells of your cat or dog contains the precise instructions for building your pet. DNA from one cell of an apple tree holds all the information required to create the entire apple tree.

DNA is short for "deoxyribonucleic acid." Even though it has a long name, DNA is so tiny that you can't get a clear look at it with an ordinary microscope. Scientists didn't even realize that this **molecule** existed until 1869. Then they understood that it was important and **complex**, but they couldn't understand how its **atoms** were arranged. So how did we learn about the double helix? Doing so involved many people, a lot of work, and, most of all, the **determination** of one brilliant woman.

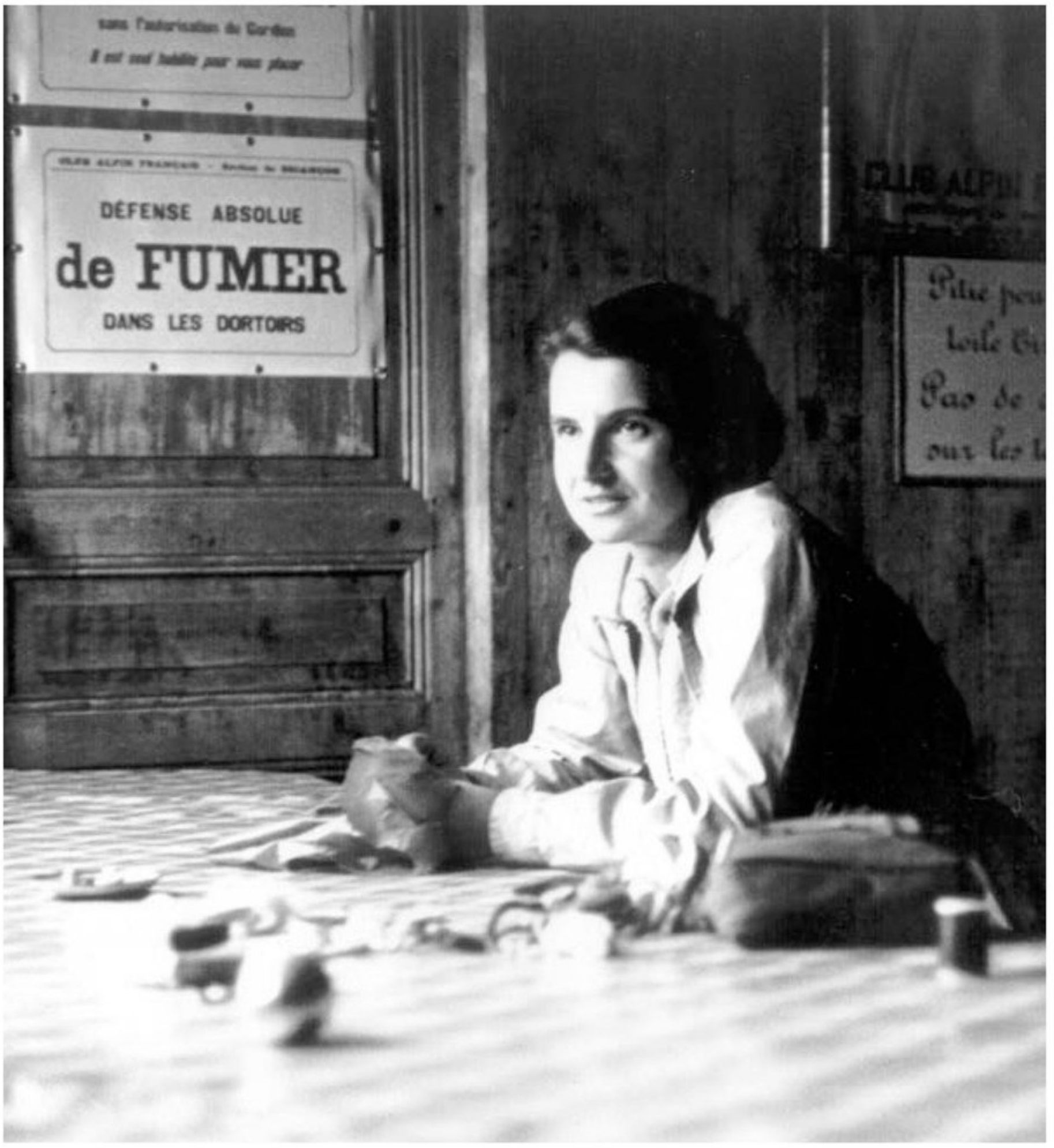
Rosalind Franklin

In 1920, Rosalind Elsie Franklin was born in England. Even as a little girl, she was remarkably smart—to the point that some people were a little scared of her. At six years of age, she enjoyed doing math problems for fun, and she always got them right. In England in the 1920s, many people thought it was a waste of time for girls to study math rather than just getting married and having babies.

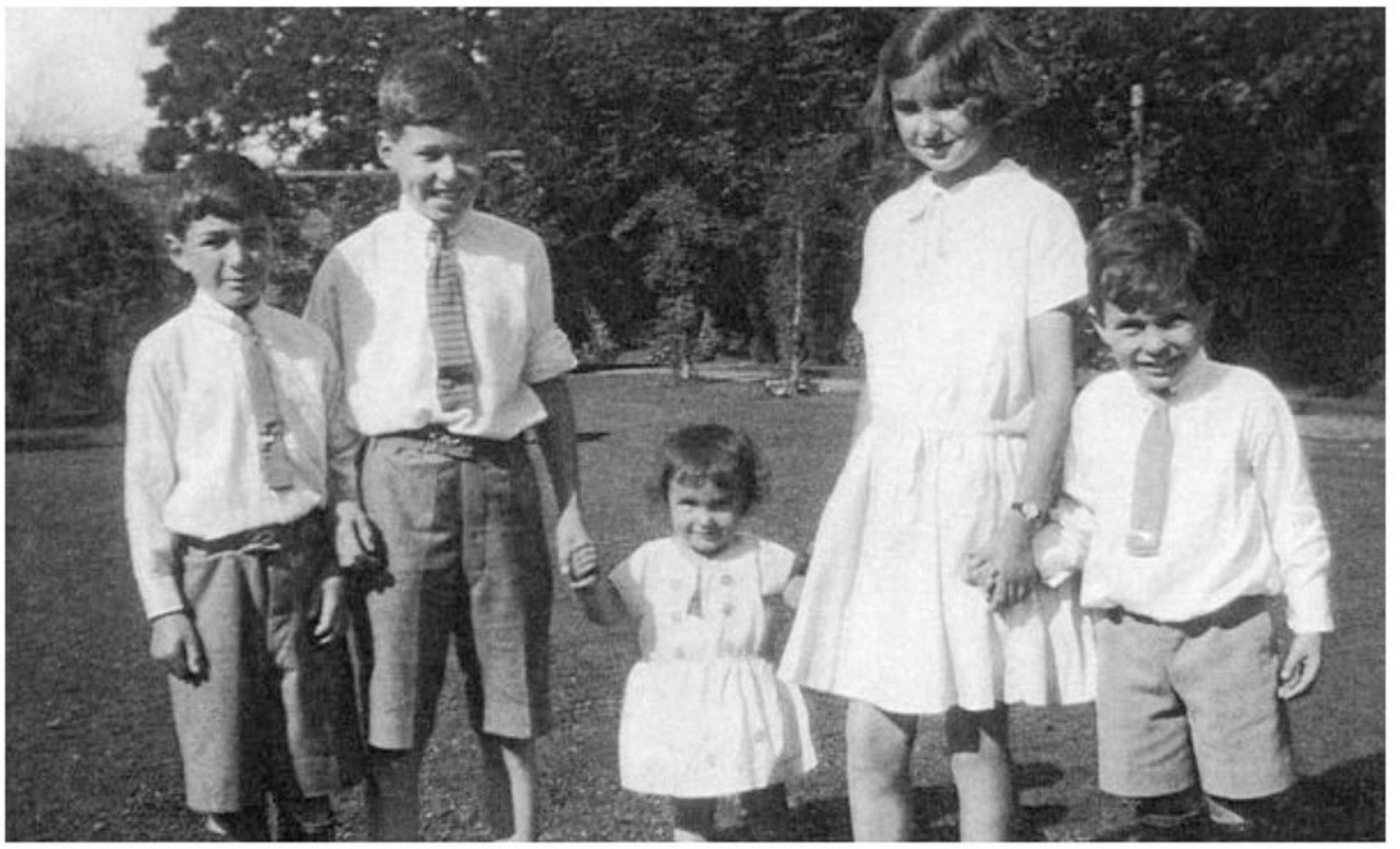


Rosalind at a young age

Rosalind loved school, but she wasn't merely a bookworm—she loved playing sports, too. At her school, girls played hockey, cricket, and tennis, and Rosalind was good at them all. She enjoyed hiking with her family and friends, but her favorite activity was mountain climbing. During her entire life, Rosalind found nothing more relaxing than traveling to other countries to climb new mountains.



Rosalind Franklin loved to travel to other countries.



Rosalind with her younger sister and brothers

One thing she never put up with was listening to people when she knew they were wrong. Although she loved her father, she thought he was old-fashioned and too **conservative**. When she felt he was wrong, she didn't hesitate to express her opinion. Sometimes they fought, but mostly they debated, discussing their disagreements without getting angry.

Her favorite: mountain climbing

A Life in Science

At the age of twelve, Rosalind decided to become a scientist. Her father didn't approve of her decision, but by the time she was old enough for college, he knew better than to argue the point with her. Rosalind always accomplished what she committed to do, and in 1938, she attended Cambridge University in England. She even won a **scholarship** because she earned the highest score on the **chemistry** exam.

Rosalind at age 26

At Cambridge, women had to cope with **gender discrimination**. For every nine men admitted to the university, only one woman was allowed to enroll. There was a **double standard**: women were required to obey different rules than men about where they could go and what they could do. Although she had to put up with unequal treatment, Rosalind was thrilled to study chemistry, physics, and math. She became an expert in X-ray crystallography, a way of using X-rays to examine molecules.

In 1939, when World War II began, most British men enlisted in the military, and everyone who couldn't fight wanted to work on something that would help England defeat Germany. Even Princess Elizabeth worked as a mechanic during the war years! By 1942, when she was almost finished with school, Rosalind found a job in the coal **industry**. Coal, an important fuel, was used to heat homes, power factories, and run machines during the war.

Using X-ray crystallography, Rosalind made discoveries about coal's structure—how the atoms in its molecule were put together. Her work advanced science, industry, and the war effort. Other experts on molecules admired Rosalind's skill in the laboratory. She finished her Ph.D., the highest degree of education, in 1945.

Even Princess Elizabeth, the future queen of England, worked as a mechanic to support the war effort.

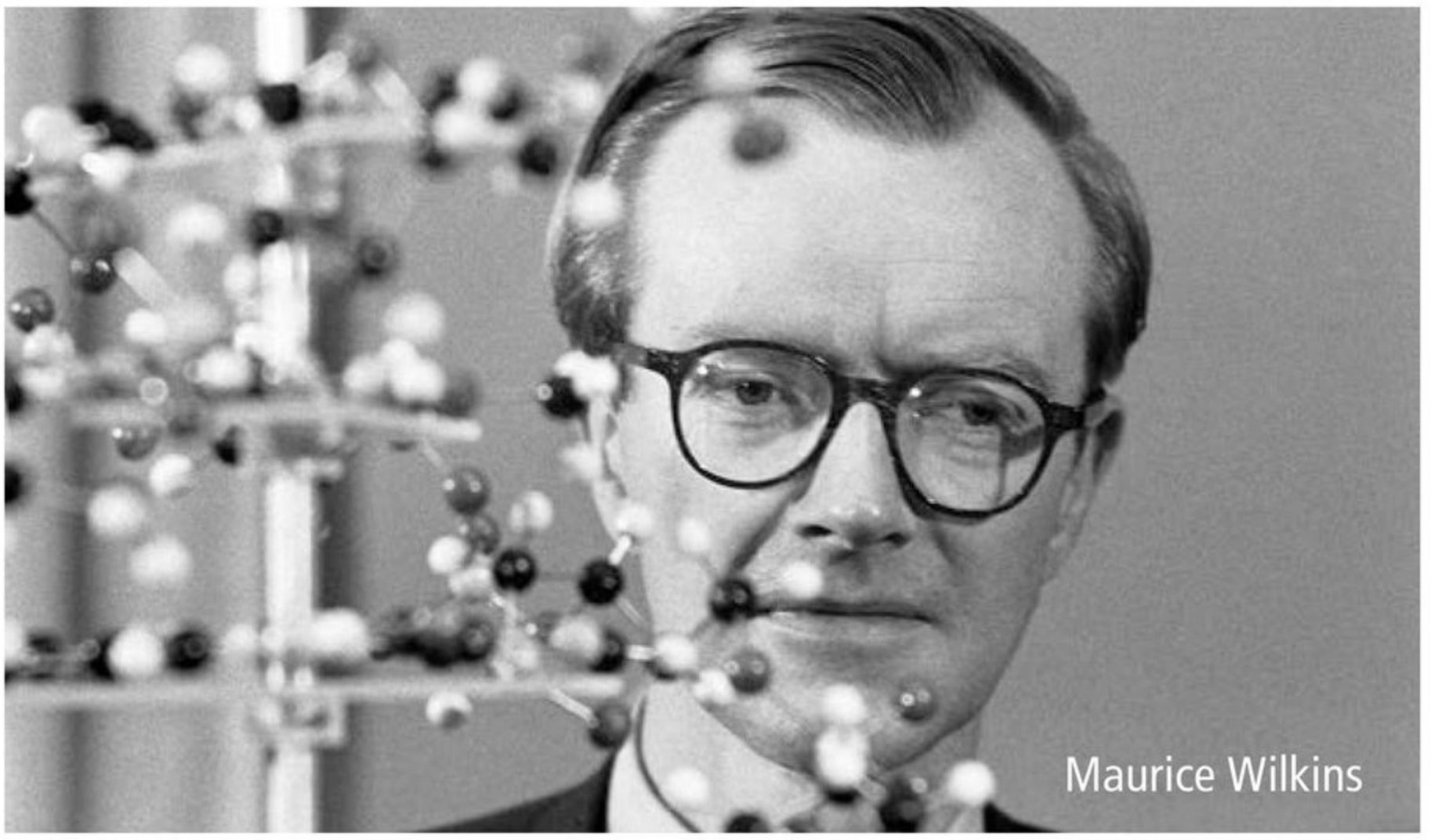
After the war, in 1947, Rosalind worked in France. She preferred France to England because the French people didn't seem as old-fashioned as her father and many other English people. Her coworkers believed in **equality** between men and women, and she got along well with them. They worked hard but also took time to have fun. Every day, they lunched at their favorite *café* and then brewed coffee with the same lab equipment they used for experiments. That might sound strange, but for Rosalind, cooking was simply a form of chemistry. She loved France and would have remained there forever, but her family missed her and begged her to come back to England.

Rosalind in the Tuscany region of Italy. She loved the relaxed way of living and working that she found in France and Italy.

The Secrets of Life

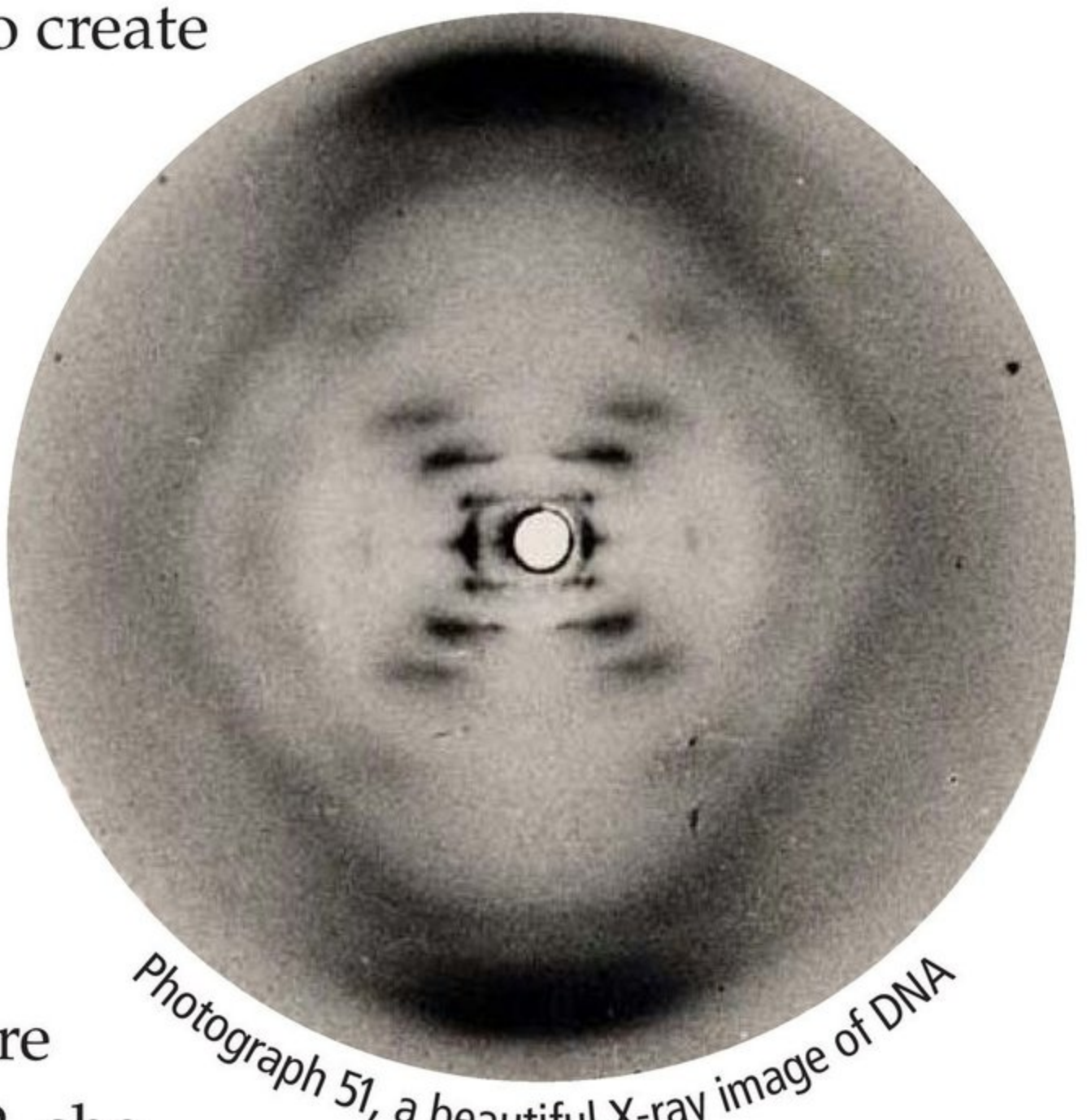
King's College, London, where Rosalind found a new job in 1951, differed greatly from her workplace in France. Gender discrimination was accepted as part of the culture at the college. The campus even included dining rooms where women were not allowed. Rosalind couldn't adjust to this environment. The men played **pranks** on each other, which Rosalind disliked because lab work was serious to her. In addition, she didn't approve of how the men gave their coworkers nicknames. They called her Rosy, a nickname that she hated.

Her boss, John Randall, was a brilliant scientist, but he wasn't a great boss. He knew how to bring talented scientists together, but he didn't understand how to keep them happy. Still, he encouraged Rosalind's work. In 1951, scientists were sick of war and death, so they found inspiration in studying molecules from living things. They wanted to know where plants and animals stored their **genes**, which hold the biological information that guides growth and development. Some people thought the genes were located within DNA, which exists in every cell of every plant and animal. John Randall asked Rosalind to study DNA to explore this possibility.


Maurice Wilkins

Maurice Wilkins was a scientist who worked in Rosalind's lab. Rosalind and Maurice had the same amount of education and experience, but they doubted that they had anything else in common. They were supposed to be peers, or equals, but they didn't get along and couldn't cooperate. John Randall didn't help the situation, and some of his actions seemed designed to encourage them to fight. Some people thought Maurice discriminated against Rosalind because she was a woman. Other people remember that Maurice was the one who suggested to John Randall that he ask Rosalind to study DNA in the first place. Regardless of Rosalind's relationship with Maurice, everyone involved with the project recognized that Rosalind took the finest X-ray pictures. King's College needed Rosalind's talent to discover the secrets of life.

Determined as always, Rosalind threw herself into her work. When her equipment or techniques didn't work, she improved them herself. X-raying DNA wasn't a simple process. It took one hundred hours to create one picture. Sometimes the results were blurry or were taken from a bad angle, but she **persevered**. Her pictures kept improving and drawing more attention. In 1952, she took Photograph 51, the most amazing picture of DNA that anyone had ever taken.



Photograph 51, a beautiful X-ray image of DNA

For every photograph she took, Rosalind spent days doing math to understand her results, recording everything in her notebooks. She wasn't worried about how long it took because it was most important to her to be certain about her conclusions before she shared them with the world. She didn't know everything, but she was learning more than anyone else ever had about the DNA molecule.

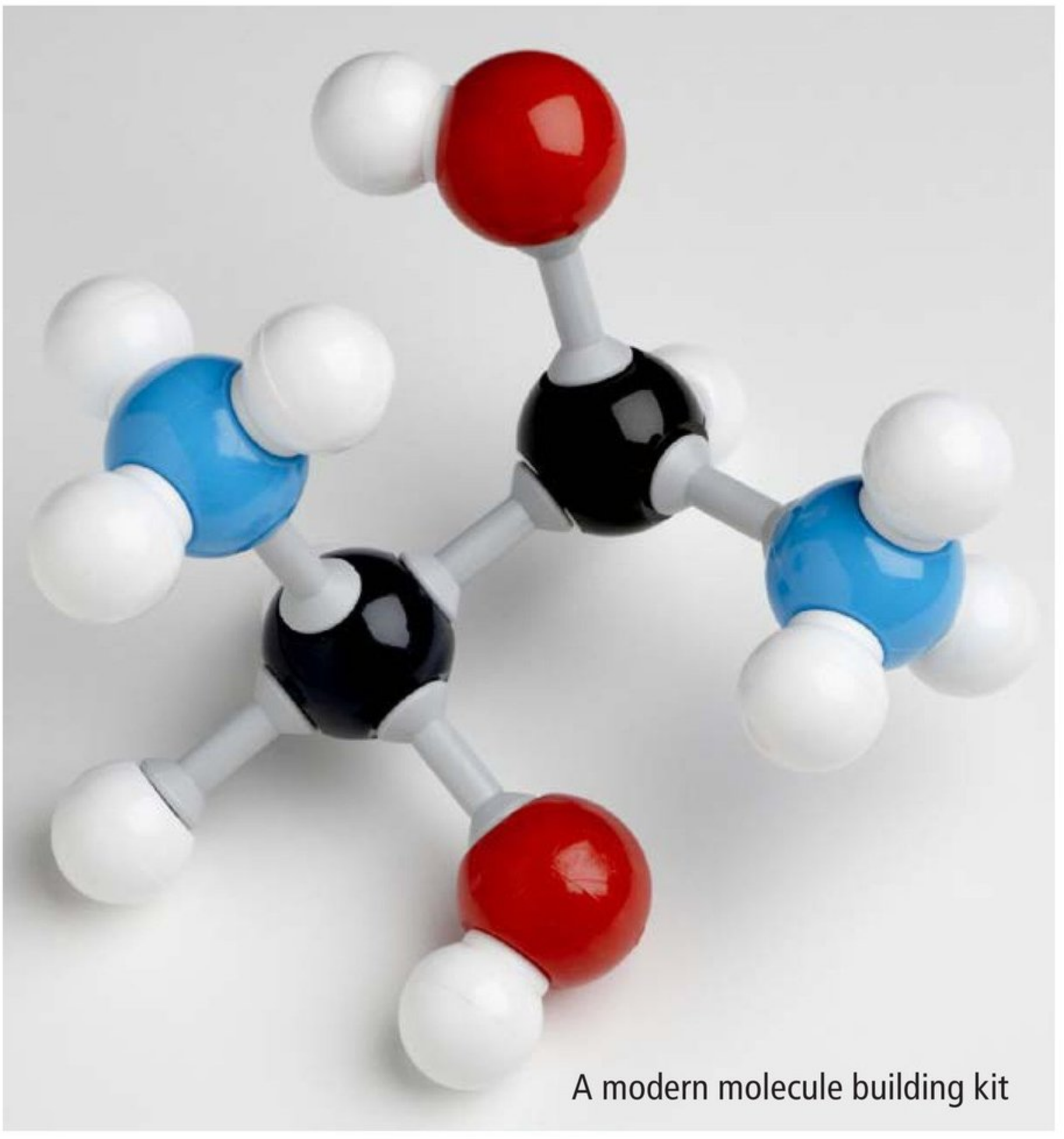
Watson and Crick's Big Idea

Rosalind Franklin wasn't the only person trying to discover the shape of DNA. Maurice Wilkins was, too, as well as a famous American chemist named Linus Pauling. And not far away, back in Cambridge, James Watson and Francis Crick were working just as hard.

Rosalind was an experimental scientist; she performed tests under controlled conditions to try to prove or disprove scientific **theories**. Watson and Crick were theoretical scientists; they read others' experiments and discussed ideas. While Rosalind worked with X-rays and DNA in the laboratory, Jim and Francis built big models out of pieces of metal that represented atoms. Their models were similar to the building toys that many kids play with in preschool. Rosalind doubted that they could learn much that way, and she and Jim argued frequently. It didn't help matters that he liked to tease her and call her Rosy behind her back.

Francis Crick and Jim Watson

It was a shame that Jim and Rosalind argued so often because Jim was really interested in her work and knew that her photographs could help him. Jim and Francis wanted to be the first to understand DNA so they would achieve fame and honor for the discovery. They believed that they were racing Linus Pauling, Rosalind Franklin, and every other scientist to the solution—except that nobody else thought of it as a race.



A modern molecule building kit

Jim Watson suspected that Rosalind was close to finding the answer. He went to hear her **lecture** about her work, and he visited her lab, where they fought, as usual. When Rosalind wasn't looking, Maurice Wilkins showed Jim Photograph 51. Jim was astonished and ran back to Cambridge to tell Francis Crick. Later on, they gathered more of her work and a copy of her photograph. They didn't ask her if they could see it because they knew she would refuse, so they were sneaky. Using Rosalind's photograph and the help of another chemist, they built a model of the double helix just as we know it looks today.

Jim Watson used Rosalind's work to discover the shape of DNA.

Jim and Francis wrote an article to inform the world about the double helix. Rosalind's work was published in the same magazine, but Jim and Francis didn't **acknowledge** that they had based their work on hers. They implied that their discovery was made without her help and that her work only proved their theories. They became famous for discovering the structure of DNA, and Rosalind never knew that they had stolen her work. No one knew because Jim and Francis didn't give her credit.

Happier Days

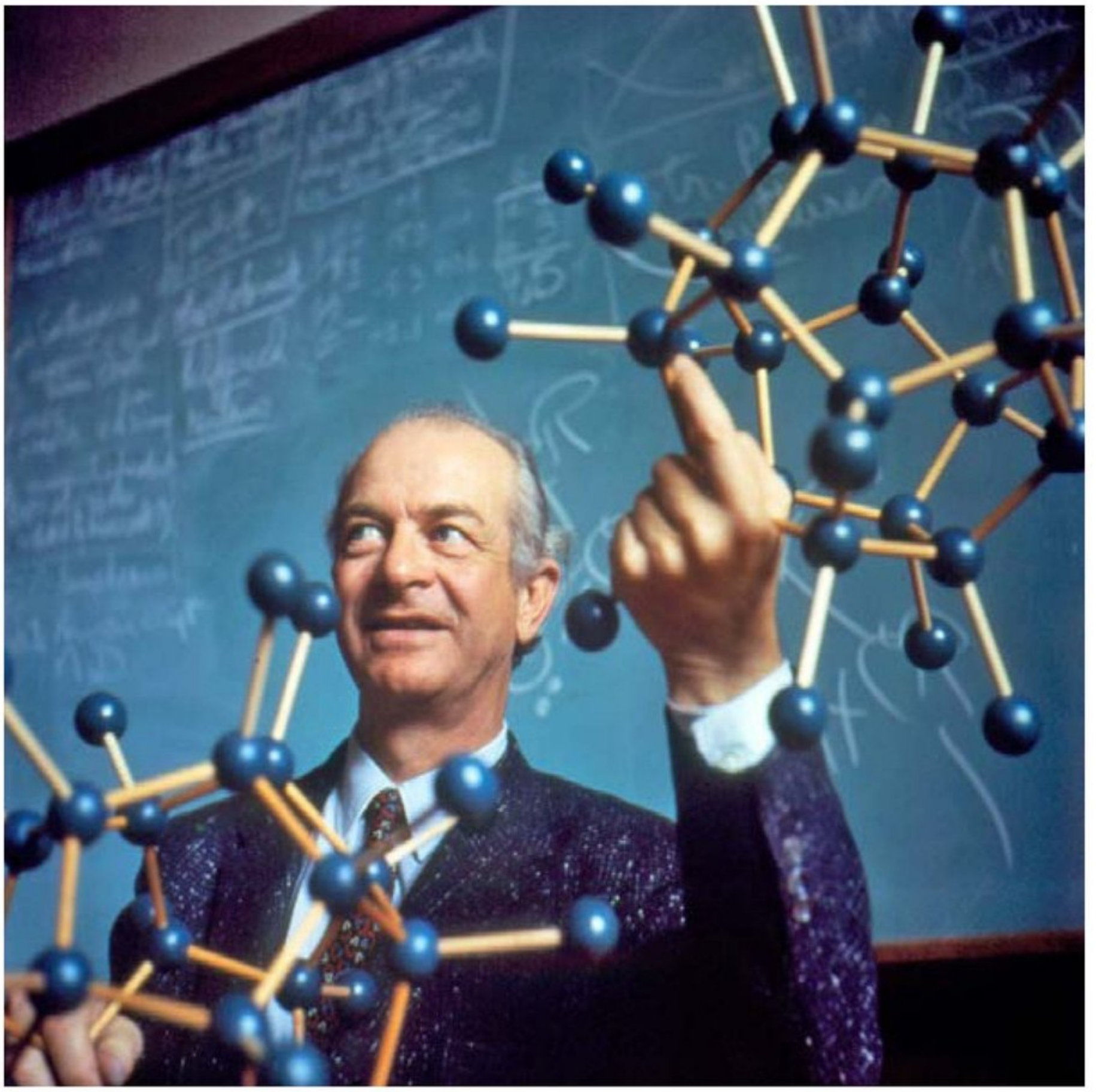
As soon as possible, Rosalind found another job. Even though Birkbeck College had less funding, crumbling buildings, and **inadequate** equipment, she liked it better than King's. She was the boss, with a team of talented and respectful scientists working for her. They studied **viruses**—diseases that attack, sicken, and sometimes destroy living things.

As a result of her important discoveries, other scientists invited her to lecture all over Europe. Traveling and speaking always delighted her. She felt honored to visit America, where many scientists were eager to hear her ideas. As always, she found time for hiking and climbing new mountains in addition to science and learning.

Everywhere she traveled, people found her extremely knowledgeable and incredibly talented, although she still got angry when she heard things she didn't like. She continued making new friends. She even forgave past disagreements and became friends with Jim Watson, Francis Crick, and Maurice Wilkins.

Rosalind Franklin was only 37 when she died.

On her second trip to America, Rosalind began to feel sick. She was only thirty-seven when she died in 1958. She had **cancer**; no one can say for certain why. Perhaps it was written in her DNA, but we know that overexposure to X-rays can cause cancer. It might have been her excellent and determined work to take pictures of DNA and other molecules that caused her to die so young.



Linus Pauling was a world-famous scientist who also worked to understand the structure of DNA.

During her illness, she continued working. She also spent time with all her favorite people, mostly her family. She even vacationed with Francis Crick and his wife. After she died, Jim and Francis began to publicly acknowledge the importance of her work. They admitted that they couldn't have cracked the complex structure of DNA without the help of her photograph. But Rosalind never knew they had used her work without her knowledge.

Rosalind Remembered

Four years after Rosalind died, Jim, Francis, and Maurice won the Nobel Prize in Chemistry for their work on DNA and genetics. Rosalind herself might also have won if she hadn't died, but only living people can win the Nobel Prize.

Some of the 1962 Nobel Prize winners

Most people forgot Rosalind, while Jim and Francis became famous for their work. In 1968, Jim Watson published a book about their discovery. He wrote some rude things about Rosalind, even while showing how much he needed her work. He made fun of how she looked and how she dressed. He insisted that she never understood DNA because she disagreed with him. In reality, she never said anything until she was absolutely sure it was true. Jim was the opposite; he loved to talk about his ideas, even if he couldn't prove them.

Before he published his book, Jim Watson showed it to other people. Maurice Wilkins, Francis Crick, and Linus Pauling all urged him not to write about Rosalind the way he had because it was mean and untrue. Jim didn't want to change his story, so he added one paragraph at the end, saying that he didn't believe those terrible things anymore. He admitted that he and Francis wouldn't have understood DNA without Rosalind and that she had to work twice as hard just because she was a woman. Most people who knew Rosalind did not think this one paragraph did her justice.

Partly because of the awful things Jim Watson wrote, Rosalind got more famous. Today, more people honor Rosalind and her work. In 1984, Cambridge opened the Rosalind Franklin Design, Technology, and Engineering Workshop. In 2000, King's College named a new lab the Franklin-Wilkins Building after her and Maurice. Books and movies have also been made about her life.

The University of Cambridge is one of several institutions that have named buildings after Rosalind.

Rosalind never set out to prove that women made great scientists—she just knew that she loved her work. Sometimes she **resented** people standing in her way, and sometimes she argued when it might have been better to compromise, but nothing ever kept her from doing her job. Even when she was sick, she kept working until the end of her life. Her determination to do her work well, even in the face of discrimination, led to one of the most important discoveries in the history of science.

Rosalind using a microscope

Glossary

acknowledge *(v.)* to thank or give credit to someone for something he or she did (p. 17)

atoms *(n.)* the smallest units of chemical elements (p. 5)

cancer *(n.)* a disease that causes body cells to grow out of control (p. 18)

cells *(n.)* the smallest independently functioning units in an organism (p. 4)

chemistry *(n.)* the branch of science that studies how chemical elements and compounds change when heated, cooled, or combined (p. 8)

complex *(adj.)* having many different parts; difficult to achieve or understand (p. 5)

conservative *(adj.)* traditional and resistant to change (p. 7)

determination *(n.)* an attitude of willingness to work hard to reach a goal (p. 5)

DNA *(n.)* the material inside the nucleus of cells that carries genetic information (p. 4)

double helix *(n.)* a spiral made up of two strands (p. 4)

double standard *(n.)* a set of rules applied differently to different groups, resulting in unfair treatment (p. 8)

equality *(n.)* the condition in which everyone has the same rights (p. 10)

gender discrimination *(n.)*	the unfair treatment of a person or group, based on gender (male or female) (p. 8)
genes *(n.)*	basic units of heredity that transfer traits from one generation to the next (p. 11)
inadequate *(adj.)*	not sufficient for a task (p. 17)
industry *(n.)*	the making, selling, and transporting of goods or services (p. 9)
lecture *(v.)*	to give an educational talk on a topic (p. 16)
molecule *(n.)*	the smallest part of a substance that can exist by itself, made of one or more atoms (p. 5)
persevered *(v.)*	continued on a task or mission despite challenges or obstacles (p. 13)
pranks *(n.)*	practical jokes (p. 11)
resented *(v.)*	felt anger caused by having been wronged by a person or group (p. 22)
scholarship *(n.)*	financial aid given to a student to help pay for his or her education (p. 8)
theories *(n.)*	possible scientific explanations that have not been proven true (p. 14)
viruses *(n.)*	microscopic organisms that infect the body; diseases caused by a virus (p. 17)

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