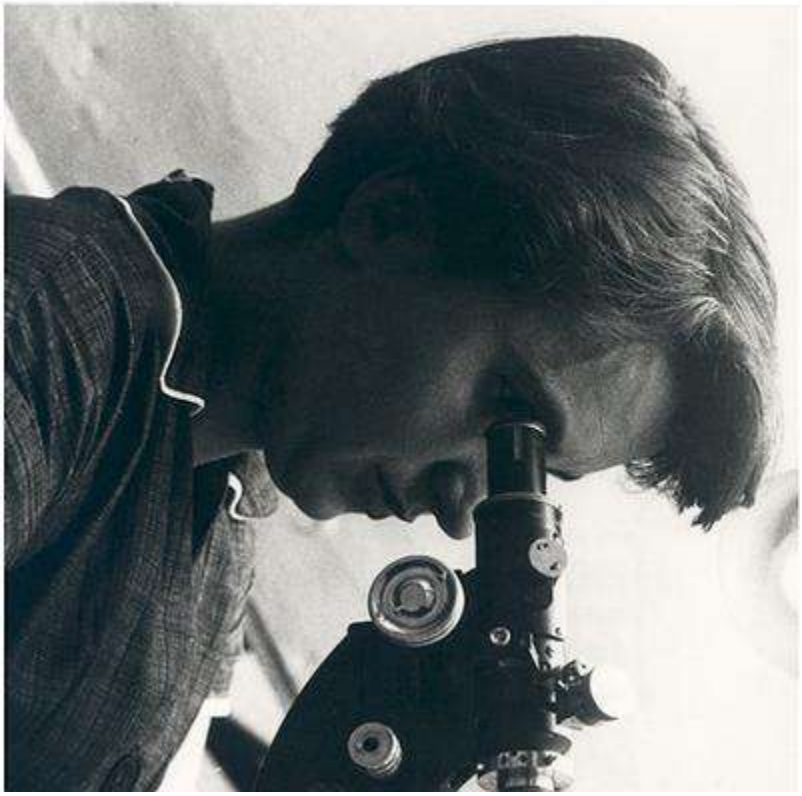
Three English Biochemists Unravel DNA to Unlock the Mystery of Life



By Cynthia Stokes Brown, Big History Project, adapted by Newsela staff
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In 1953, three English biochemists helped unlock the mystery of life by determining the structure of the DNA molecule. Found in all life on Earth, DNA contains the information by which an organism regenerates its cells and passes traits to its offspring.

Charles Darwin had successfully proposed the theory of natural selection, but he didn't understand how parents pass characteristics to their offspring. Slight changes when passing down traits made evolution possible.

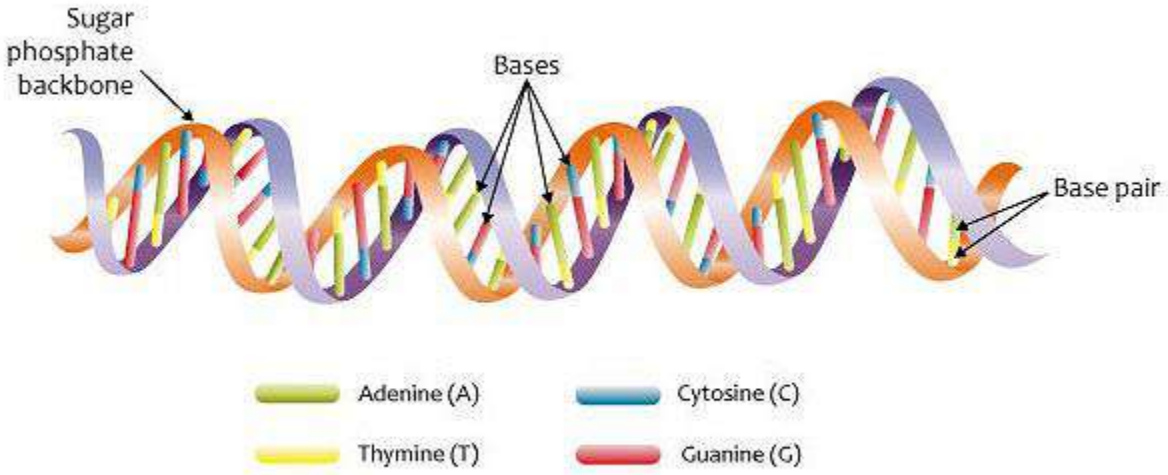
By the middle of the twentieth century, this was still not well understood. There were major breakthroughs earlier in the century in physics, such as Albert Einstein's Theory of Relativity, and atomic bombs that used nuclear fusion.

After World War II, scientists began trying to understand the physical basis (atomic and molecular) of biology. In the 1950s, biochemists realized that DNA delivered the instructions

for copying a new organism. A yard of DNA — deoxyribonucleic acid — is folded and packed into the nucleus of every cell in pairs called “chromosomes.”

The parts of DNA

DNA has three parts: a type of sugar called “ribose,” a phosphate responsible for its acidity, and four kinds of bases — adenine (A), thymine (T), guanine (G), and cytosine (C).



These four bases seemed too simple to pass on all the information needed to create a new organism. Biochemists didn’t understand DNA’s structure and how it worked. However, these four bases combine like letters of an alphabet to describe complex variations in genetic traits.

The question became how to study the DNA molecule. Biochemists wanted to understand its structure. They thought this was the key to understanding how it coded the instructions for copying a new organism.

They began taking X-ray images of crystals of DNA, believing that its crystallization meant it must have a regular structure. The pattern of the X-rays bouncing off atoms gave information about their location in the molecule.

One of the pioneers of this technique, called “X-ray crystallography,” was Linus Pauling, who worked at the California Institute of Technology, in Pasadena. In the early 1950s, Pauling, a prominent chemist, seemed likely to unlock the mystery of life, since he had already concluded that the general shape of DNA must be a helix, or spiral.

The race is on

The victory, however, went to three people working in England, in one of the great scientific races of all time. One, Rosalind Franklin, was working at the University of London. The other two, James Watson and Francis Crick, were friends and lab mates some 50 miles away at Cambridge University, where they worked cooperatively and shared their ideas.

Franklin was from a wealthy, influential family in London. After earning a PhD from Cambridge in physical chemistry, she began to study DNA at the University of London, in 1951. Franklin became extremely skilled in X-ray crystallography. She was able to produce clear and accurate images of DNA crystals by using fine-focus X-ray equipment and pure DNA samples.

Over at Cambridge, Crick was 35, working on his PhD in the crystallography of proteins. He had grown up in a small English village.

Watson was only 23 in 1951. He had grown up in Chicago, performed on the national radio show "Whiz Kids," entered the University of Chicago at age 15, and secured his doctorate from the University of Indiana at just 22. He was at the Cambridge lab to learn crystallography.

Between 1951 and 1953, Franklin examined her precise X-ray diffraction images. She reasoned that 1) DNA takes two forms (shorter-dryer and longer-wetter), 2) the sugar-phosphate backbones must be on the outside, and 3) the molecule looks the same upside down or right side up.

In late 1952, she recorded an especially clear X-ray image. Her colleague, Maurice Wilkins, showed the image to Watson in 1953 without telling her or asking her permission.

A spiral shape

When Watson saw the image, he knew at once that DNA had to be a helix. He returned to his lab to begin making models out of sheet metal and wire.

Watson and Crick built models to try to visualize DNA. How many strands did the helix have? Which direction did the strands run? Were they on the inside or the outside? How were the four chemical bases arranged?

Franklin believed more X-ray images of better quality would answer the questions. But Watson and Crick knew they were racing against Pauling. They felt making models would speed up the answers.

Using paper models and combining them in different ways, they visualized a structure that solved the puzzle. If two of the bases were bonded in pairs (G with C), they took up the same space as the other pair (A with T). Hence, they could be arranged like steps on a spiral staircase inside of two strands of sugar-phosphates running in opposite directions.

These insights occurred to Crick and Watson in February 1953. They announced at lunch in their usual pub that they had found the secret of life.

The news gets out

The April 25, 1953, issue of *Nature* published Crick and Watson's article, "A Structure for Deoxyribose Nucleic Acid." Wilkins and Franklin, who both accepted Crick and Watson's solution, wrote accompanying articles.

By the 1960s, scientists had accepted the double helix as the structure of DNA. In 1962, Wilkins, Watson, and Crick received the Nobel Prize in medicine/physiology for their work.

Franklin could not share in the prize. She had passed away in 1958 of ovarian cancer. She was just 37. Franklin had a family history of cancer, but her exposure to X-rays may have contributed to her death.

In any case, she may not have had the chance for the award had she been alive. Crick and Watson never told Franklin that they had used her images. In *Nature*, Watson and Crick only mentioned her briefly. She wasn't credited in Watson's book about the discovery, *The Double Helix* (1968).

It wasn't until much later that Watson finally admitted in public that he and Crick could not have found the double helix in 1953 without Franklin's experimental work. If she had survived, would she have been acknowledged and shared in the prize?

In their 1953 article, Watson and Crick did not discuss how DNA copies itself.

Five weeks after their first article in *Nature*, Crick and Watson published another article proposing the idea that, to make a copy, the double helix unzips, or separates, into two strands. Each strand is a backbone of sugar-phosphates with the four bases attached in some sequence.

Then the cell uses each strand as a template to assemble another DNA strand from free-floating complementary bases: A picks up T, while C picks up G. This would result in two identical DNA molecules, one a copy of the other. Occasional mistakes in copying enable evolution to occur and each organism to be unique. This idea has been confirmed, while the means for carrying it out have proved to be quite complex.

Crick continued his research in England until 1976, when he moved to the Salk Institute for Biological Studies in California, where he died in 2004. Watson returned to the United States, researching at Harvard from 1956 to 1976. He helped establish the Human Genome Project in the early 1990s and served as president of the Cold Spring Harbor Laboratory in New York, until his retirement in 2007.