The structure of DNA: Cooperation and competition

Sometimes, one person or a few people get all the credit for a scientific discovery. But this doesn't mean that they worked alone. Scientists share evidence and ideas with each other all the time, and this helps make new discoveries possible. Here, we'll learn how a whole community of scientists—and four in particular, James Watson, Rosalind Franklin, Francis Crick, and Maurice Wilkins—helped unlock one of the great secrets of life ….

Scientists have always wanted to know how family traits are passed from parent to child. By the 1940s, they had discovered some important clues. They knew that family traits are carried on parts of the cell known as chromosomes. They knew that chromosomes are made up of two components: proteins and DNA. And they knew that the traits were carried by the DNA in chromosomes, not by the proteins. But how could DNA carry all the information needed to make a whole organism? The answer might be in the 3-D structure of the molecule. The scientists knew that DNA was built from sugars, phosphates, and bases. How did these building blocks fit together to store genetic information?

Many different scientists wanted to answer this question, and there was a sense of competition over who would figure out the problem first. Maurice Wilkins, a nuclear physicist, and his student Raymond Gosling entered the race by trying out a new technology, called X-ray diffraction. They shot X-rays through DNA and then observed how the X-ray beams scattered. From the way the beams scattered, they picked up another clue: DNA has a straightforward, repeating structure, and it is shaped like a corkscrew—or a helix.

Wilkins went to a conference to tell other scientists about this clue. There, James Watson, a bird biologist, heard about the new discovery and decided to enter the race for himself. Watson told Francis Crick, a former physicist, about the new clue, and Crick decided to enter the race along with Watson.

Meanwhile, Maurice Wilkins had picked up another teammate. Rosalind Franklin, who specialized in using X-rays to study molecules, joined the lab that Wilkins and Gosling were in. Franklin and Gosling started working together to shoot X-rays through DNA and see how the X-rays scattered. They found that the DNA scattered the X-rays in different directions depending on how humid it was. This meant that DNA must come in two forms: a dry form and a form that DNA takes on when water molecules cling to it. They also reasoned that since the phosphates attract water, they must be on the outside of the molecule. These were important clues—but Franklin and Gosling still didn't know exactly how the molecule was built.

Meanwhile, instead of shooting DNA with X-rays, Watson and Crick decided to try a different approach: model building. Molecular models are a bit like tinker toys with balls representing the atoms and sticks representing the bonds between atoms. Previous scientists had done a lot of work to figure out the shapes in which different atoms can bond to one another. Watson and Crick hoped that they could build a model of DNA that fit with everything that was known about molecular bonding and with all the clues to DNA's structure that other scientists had discovered. This model would serve as a hypothesis about the structure of DNA—but to build it, they needed more clues.

Franklin provided those clues when she gave a talk that Watson attended. In the talk, she explained what she and Gosling had just learned about DNA's two forms. Watson and Crick built a model based on these clues and invited Franklin, Gosling, and Wilkins to come take a look at it. Unfortunately, Watson had forgotten some of the details that Franklin had described. After she saw the model, Franklin explained how their hypothesis didn't really fit with the evidence that she had collected. They would have to reject their first hypothesis and try again.

While Watson and Crick went back to the drawing board, Franklin and Gosling stuck with their X-ray work, concentrating on the dry form of DNA. The X-rays yielded another clue: DNA is symmetric—it looks the same when turned upside down and backwards. Then a lucky accident happened. Some DNA they were studying accidentally got too wet. By mistake, they ended up with the wet form of DNA—but they also got a clear image of how the X-rays scattered as they passed through it. This image, known as B51, supported the other clues about DNA that they'd discovered, but also revealed some new clues about the molecule's width and how tightly it twists. They were making progress!

Unfortunately, Franklin and Wilkins weren't getting along. They both wanted to work on DNA and were stepping

on each others' toes. Because of this, Franklin decided to leave. This left Gosling without an advisor. He decided to get Wilkins' advice and showed him the beautiful image that Franklin had taken, B51, to see what he'd make of it. Wilkins was impressed. When Watson came for a visit later that month, Wilkins showed him the image—and this time, Watson wrote down all the details!

Watson told Crick about image B51 and they started building another model. But they still needed more information. Because Franklin had done most of the X-rays studies, she was the only one with all the clues—and she hadn't yet written them up to share with the rest of the scientific community. But Watson and Crick had a friend that worked in the agency that paid for Franklin's experiments. This friend had confidential information about Franklin's results, but showed them to Watson and Crick anyway. Now they had all the information that Franklin did—and they were all stuck at the same point in the problem: what single structure would fit with all these clues?

Then, Watson got a key piece of evidence about the shapes of the bases from a chemist, who told Watson that his chemistry textbooks were outdated and that the bases actually had a different shape than Watson thought! This was the last clue that Watson and Crick needed. Using the accurate shapes for the bases, they saw how they could build a model of DNA that fit with all the evidence Franklin and others had collected. The model was a double helix—two intertwined spirals—that specified how each atom was positioned.

Watson and Crick published their hypothesis, and later won the Nobel Prize with Wilkins for their work. By that time, Franklin had died. Many people wonder whether Watson and Crick really treated Franklin fairly since they didn't give her credit for discovering much of the evidence that made their discovery possible. Nevertheless, the discovery was very important and has helped us learn even more about DNA and how traits are inherited.