

How Photo 51 Shows the Double Helix of DNA

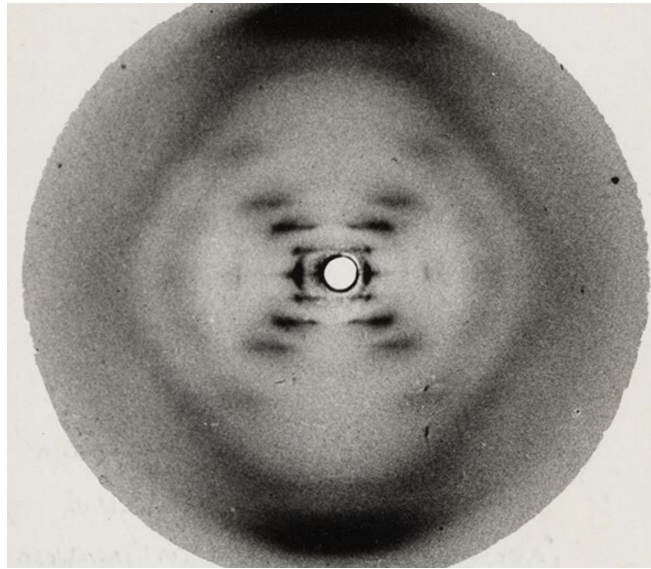


Photo 51, X-ray diffraction image of B-form DNA (Franklin & Gosling, 1952)

This is **Photo 51**, the X-ray diffraction image of DNA taken in May 1952 by Rosalind Franklin and her PhD student Raymond Gosling at King's College London. It doesn't show the molecule directly. It shows how X-rays scattered off a stretched fiber of DNA, and the pattern of that scattering encodes the molecule's shape. Here's what each feature reveals.

1. The X-shaped cross means "helix."

The most striking feature is the dark "X" of smudges running diagonally through the center. A helix seen from the side looks like two sets of parallel zigzag lines tilted in opposite directions, and each set scatters X-rays perpendicular to itself. Together they produce a cross. Crystallographers already knew this mathematically (from work on protein helices by Cochran, Crick, and Vand), so an X pattern was an immediate signature of a helical structure. The angle of the X also tells you how steeply the helix winds.

2. The horizontal bars (layer lines) give the length of one turn.

The X is made of separate horizontal dashes stacked in rows. These rows come from the repeating twist of the helix, and their spacing is inversely related to the distance the helix takes to make one full turn. From this spacing, the repeat works out to about **34 Å (3.4 nm)** per turn.

3. The dark arcs at the top and bottom give the spacing between bases.

The heavy dark regions at the very top and bottom of the circle come from something repeating at a much shorter distance: about **3.4 Å**. This is the gap between the flat bases stacked like a pile of coins inside the helix. Dividing 34 Å by 3.4 Å gives **10 base pairs per turn**.

4. The missing fourth layer line points to two strands.

Counting outward from the center along the arms of the X, the layer lines appear on rows 1, 2, and 3, but the 4th is missing or very faint. A single helix wouldn't do that. The gap is explained by two helices sharing the same axis but offset from each other along it (by about $3/8$ of a turn). Their scattering interferes and cancels on that row. That offset is also why DNA has a wide **major groove** and a narrower **minor groove**.

5. The width of the pattern gives the diameter.

The horizontal spread of the spots indicates a helix about **20 Å (2 nm)** across, which is consistent with two sugar-phosphate backbones on the outside and base pairs bridging the middle. Franklin's other measurements (on water content and density) supported placing the backbones on the outside.

The bigger picture

Photo 51 alone didn't hand over the full structure. Watson and Crick combined these dimensions with Chargaff's rule (A pairs with T, G with C) and physical model-building to arrive at their 1953 model. Watson was shown the photo by Maurice Wilkins in January 1953 without Franklin's knowledge, and her data, including a research report passed along to the Cambridge group, was crucial to the result. Franklin died in 1958 and was not included in the 1962 Nobel Prize, which is why her contribution is now widely recognized as having been underacknowledged at the time.