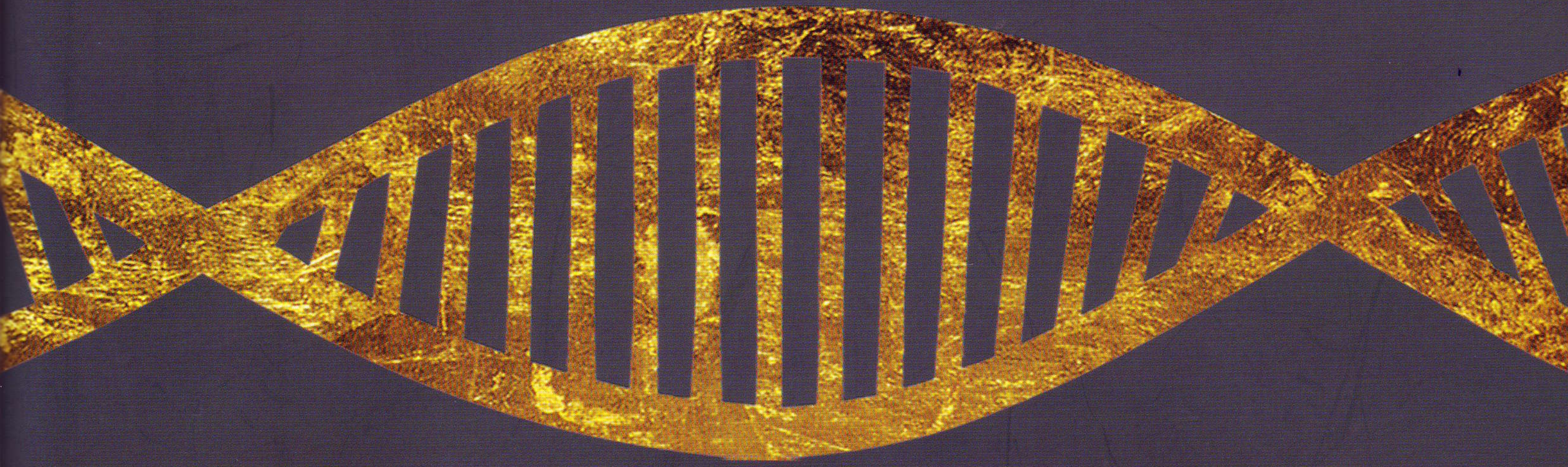
THE ANNOTATED AND ILLUSTRATED

DOUBLE HELIX

JAMES D. WATSON

WINNER OF THE NOBEL PRIZE



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SIMON & SCHUSTER

New York London Toronto Sydney New Delhi

[5] ***The Significance of the C2 Space Group***

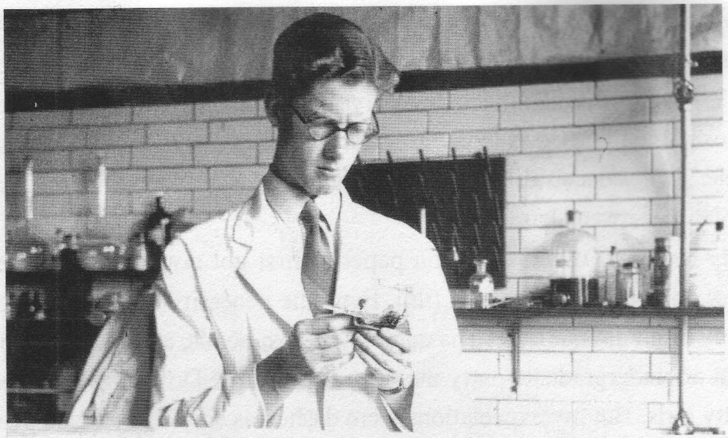
Rosalind Franklin's excellent diffraction patterns allowed her to determine the space group of the A form crystal. She had narrowed it down to three possibilities when she visited Dorothy Hodgkin at Oxford to discuss her latest results with the queen of crystallography. Hodgkin immediately saw that two of the candidates were impossible. This was in mid-1952, and so from then on Franklin knew the space group was C2. But she did not appreciate the significance of this finding, whereas Crick at once did when he came across it in the MRC report.

By this time both groups—Watson and Crick, and Franklin and Gosling—were thinking about two-chain models. What the space group told Crick was that the two chains ran with opposite polarity within the DNA molecule. In 1968, when Klug wrote his assessment of Franklin's DNA work, pointing out how close she had come to getting the structure herself, he discussed this issue:

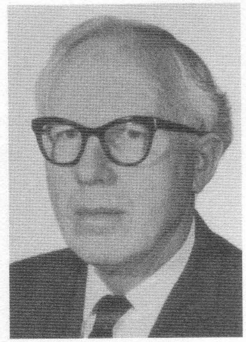
"It is interesting to note that—as she later told me—Franklin did not appreciate the significance of the fact that the space group of the A form was C2. This implies that the unit cell contains either four asymmetric molecules or else two molecules each with a two-fold axis of symmetry perpendicular to the fibre axis. The former possibility was ruled out by Franklin's density measurements, but she was not enough of a formally trained crystallographer—nor apparently was anyone else at King's—to infer that the DNA molecules must therefore possess perpendicular dyads. Of the protagonists, only Crick seems to have appreciated this fact—indeed the space group of the crystal of horse haemoglobin on which he had been working was C2, identical with that of the A form of DNA."

lar—that is, giving the sugar phosphate groups of each nucleotide identical three-dimensional configurations. But each time I tried to come up with a solution I ran into the obstacle that the four bases each had a quite different shape. Moreover, there were many reasons to believe that the sequences of the bases of a given polynucleotide chain were very irregular. Thus, unless some very special trick existed, randomly twisting two polynucleotide chains around one another should result in a mess. In some places the bigger bases must touch each other, while in other regions, where the smaller bases would lie opposite each other, there must exist a gap or else their backbone regions must buckle in.

There was also the vexing problem of how the intertwined chains might be held together by hydrogen bonds between the bases. Though for over a year Francis and I had dismissed the possibility that bases formed regular hydrogen bonds,



James Michael Creeth.



D. O. Jordan.

it was now obvious to me that we had done so incorrectly. The observation that one or more hydrogen atoms on each of the bases could move from one location to another (a tautomeric shift) had initially led us to conclude that all the possible tautomeric forms of a given base occurred in equal frequencies. But a recent rereading of J. M. Gulland's and D. O. Jordan's papers on the acid and base titrations of DNA made me finally appreciate the strength of their conclusion that a large fraction, if not all, of the bases formed hydrogen bonds to other bases.[6]

[6] **This work, begun by J. M. Gulland and D. O. Jordan at University College Nottingham, culminated with an experiment performed by their young graduate student, Mike Creeth. The paper was published in 1947.**

The work of the Nottingham group sadly ended there, as Gulland was killed along with 27 other people when the 11:15 a.m. express train from Edinburgh to London on October 26, 1947, derailed at about 12:45 p.m. at Goswick, 6 miles south of Berwick.

Train crash in which J. M. Gulland died.

J. M. Gulland.

5. "The significance of… ." Klug A. 1968. Rosalind Franklin and the discovery of the structure of DNA. *Nature* **219:** 808–844; Olby, 2009, pp. 161–163.
6. "This work, begun by J. M. Gulland… ." Haworth RD. 1948. John Masson Gulland 1898–1947. *Obit Not Fell R Soc* **6:** 67–82; Harding SE, Winzor DJ. 2010. James Michael Creeth (1924–2010). *Macromol Biosci* **10:** 696–699; Manchester KL. 1995. Did a tragic accident delay the discovery of the double helical structure of DNA? *Trends Biochem Sci* **20:** 126–128; Trench AC, Wilson GRS. 1948. Report on the derailment which occurred on October 26, 1947, at Goswick on the London and North Eastern Railway, His Majesty's Stationery Office, London.

Chapter 26

1. "Despite having reservations… ." Delbrück to E.B. Wilson, February 25, 1953, *CSHLA*.
   "Delbrück sent Watson a copy… ." Delbrück to Watson, February 25, 1953, *CSHLA*.
2. "There is a minor mystery… ." Davidson, 1950, p. 6.
3. "Watson mentions in the caption… ." Pauling, Solvay Conference Notebook, April 8, 1953, *OSUSC*.
4. "Crick did not recall… ." Crick, 1988, p. 77.

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1. "The oldest surving bridge… ." Ray, 1994.
2. "The second oldest building… ." Ray, 1994.
3. "By the early 1950s, Heffer's… ." Wilson, 2010.
4. "The original DNA model… ." MRC Laboratory of Molecular Biology, Cambridge.
5. "The DNA helix is right-handed… ." Kamminga and de Chadarevian, 2002.
6. "The Cricks' imminent exile… ." Crick to David Harker, January 21, 1953, *WL*; Olby, 2009, pp. 119–129.
7. "On March 7, 1953, Wilkins wrote to Crick… ." Wilkins to Crick, March 7, 1953, *WL*.
8. "Crick's response to Wilkins' letter… ." Judson, 1996, p. 151; Judson's interview with Crick, September 10, 1975.

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1. "Wilkins described his reaction… ." Wilkins, 2003, p. 212.
2. "Jerry Donohue appears to have had mixed feelings… ." Donohue J. 1969.

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