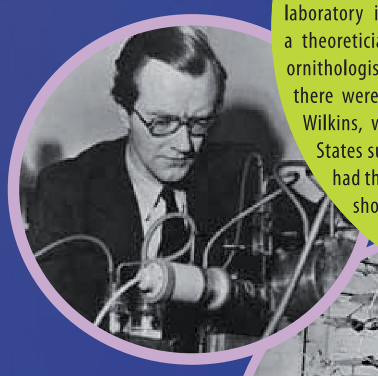
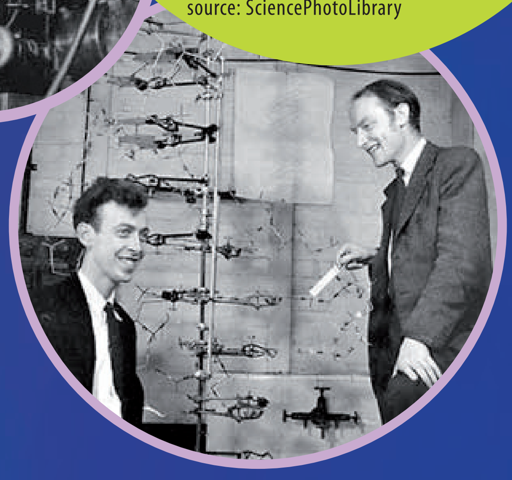
X-rays and DNA

DNA is present in all living cells. It carries the organism's hereditary information, the «secret of life». It is made up of two complementary strands formed by two regular sequences of small molecules, wound into a double helix. They can thus be duplicated identically, characterising the entire genetic make-up. It was Rosalind Franklin's image of a pseudo-crystal made of DNA fibres, obtained in 1951 by X-ray diffraction, which enabled the structure of the molecule to be determined.





Rosalind Franklin (above), James Watson and Francis Crick with a DNA model, with Maurice Wilkins

This is a novel that begins in 1869 when the Swiss Friedrich Miescher isolated the molecules of DNA from the cell nucleus. After the Second World War there was a fierce race amongst scientists to explain the structure of the molecule. In W.L. Bragg's laboratory in Cambridge, England, Francis Crick was working as a theoretician on his PhD, together with James Watson, a young ornithologist recently converted to X-rays. At King's College London there were two experimentalists, Rosalind Franklin and Maurice Wilkins, whilst the great chemist Linus Pauling in the United States suggested a three-helix structure for the DNA. Pauling had the right idea but was wrong in how to apply it. There should have been a crystal ...

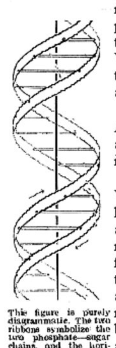
source: SciencePhotoLibrary

First image obtained by diffraction on DNA fibers

To understand the structure of DNA Rosalind Franklin produced a kind of one-dimensional crystal aligning long fibres of DNA molecules. With this bundle-shape crystal she obtained X-ray diffraction patterns of exceptional quality. Wilkins shows these photographs to Watson and Crick. They went on to assemble the pieces of the molecular puzzle, finding by trial and error the structure of the double helix DNA. Crick, Watson and Wilkins received the Nobel Prize for Medicine in 1962. Rosalind Franklin died in 1958 at the age of 38; she never received a Nobel, as the prize is reserved for living scientists.

A Structure for Deoxyribose Nucleic Acid

We wish to suggest a structure for the salt of deoxyribose nucleic acid (D.N.A.). This structure has novel features which are of considerable biological interest.

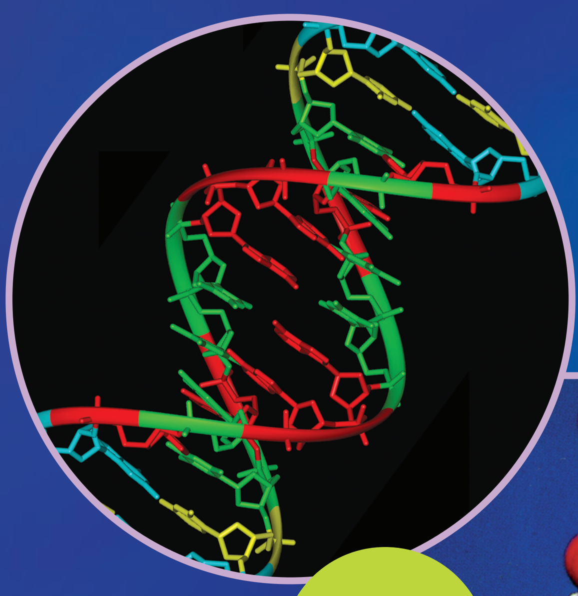


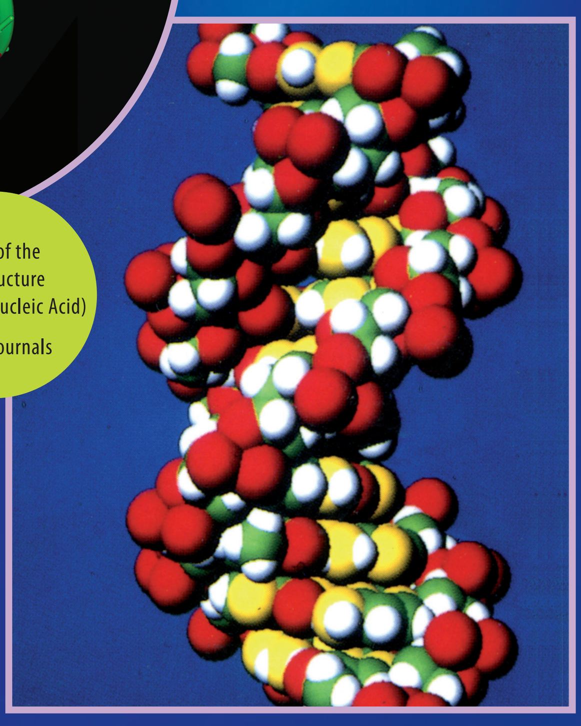
This figure is purely diagrammatic. The two ribbons symbolize the two phosphate—sugar chains, and the horizontal rods the pairs of bases holding the chains together. The vertical line marks the fibre axis.

A structure for nucleic acid has already been proposed by Pauling and Corey (1). They kindly made their manuscript available to us in advance of publication. Their model consists of three intertwined chains, with the phosphates near the fibre axis, and the bases on the outside. In our opinion, this structure is unsatisfactory for two reasons: (1) We believe that the material which gives the X-ray diagrams is the salt, not the free acid. Without the acidic hydrogen atoms it is not clear what forces would hold the structure together, especially as the negatively charged phosphates near the axis will repel each other. (2) Some of the van der Waals distances appear to be too small.

Another three-chain structure has also been suggested by Fraser (in the press). In his model the phosphates are on the outside and the bases on the inside, linked together by hydrogen bonds. This structure as described is rather ill-defined, and for this reason we shall not comment on it.

We wish to put forward a radically different structure for the salt of deoxyribose nucleic acid. This structure has two helical chains each coiled round the same axis (see diagram). We have made the usual chemical assumptions, namely, that each chain consists of phosphate diester groups joining ß-D-deoxyribofuranose residues with 3',5' linkages. The two chains (but not their bases) are related by a dyad perpendicular to the fibre axis. Both chains follow right- handed helices, but owing to the dyad the sequences of the atoms in the two chains run in opposite directions. Each chain loosely resembles Furberg's2 model No. 1; that is, the bases are on the inside of the helix and the phosphates on the outside. The configuration of the sugar and the atoms near it is close to Furberg's 'standard configuration', the sugar being roughly perpendicular to the attached base. There is a residue on each every 3.4 A. in the z-direction. We have assumed an angle of 36° between adjacent residues in the same chain, so that the structure repeats after 10 residues on each chain, that is, after 34 A. The distance of a phosphorus atom from the fibre axis is 10 A. As the phosphates are on the outside, cations have easy access to them.





Model of the DNA structure (DesoxyriboNucleic Acid)

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