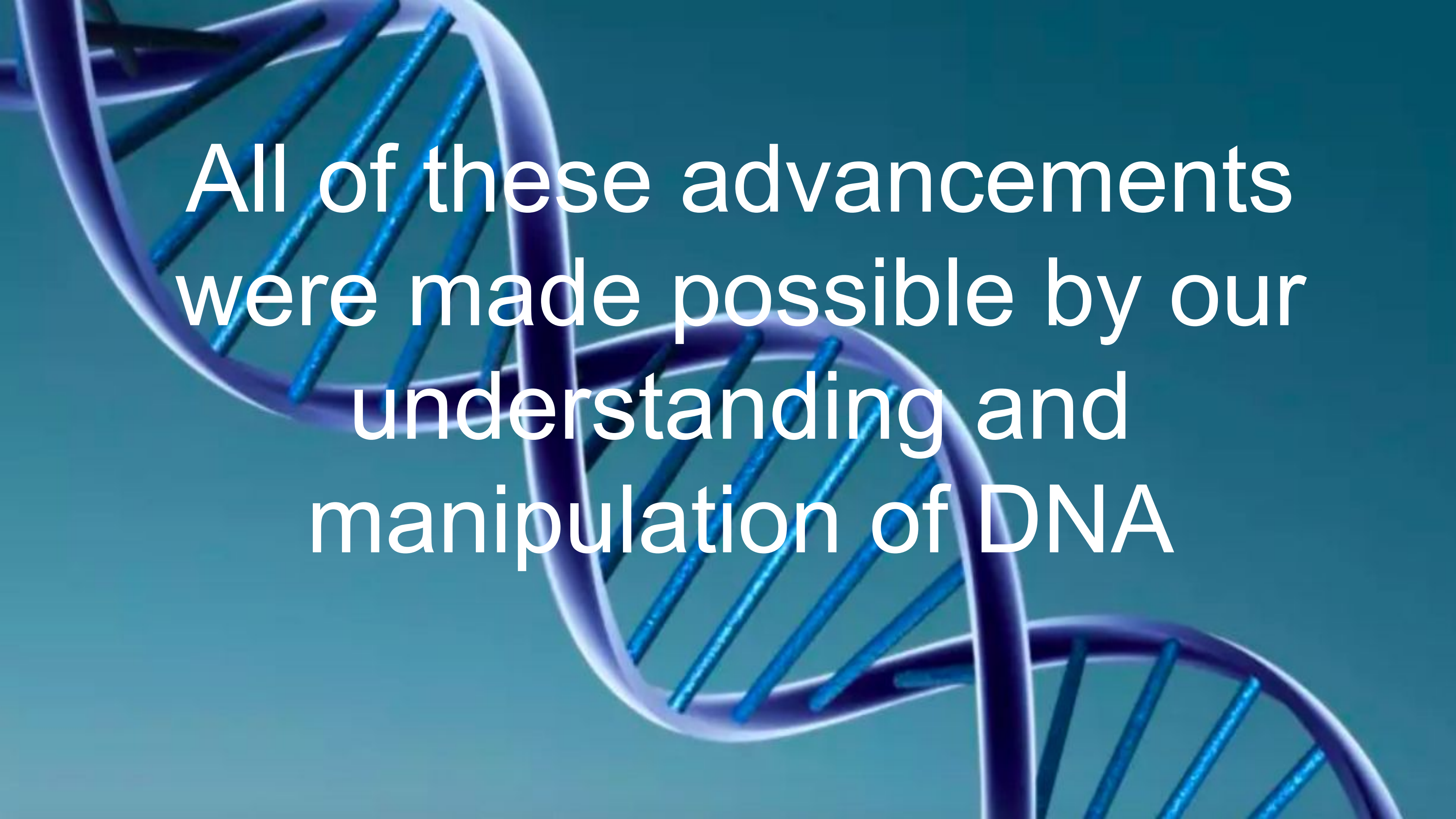
Rosalind Franklin
Chemist and Biophysicist

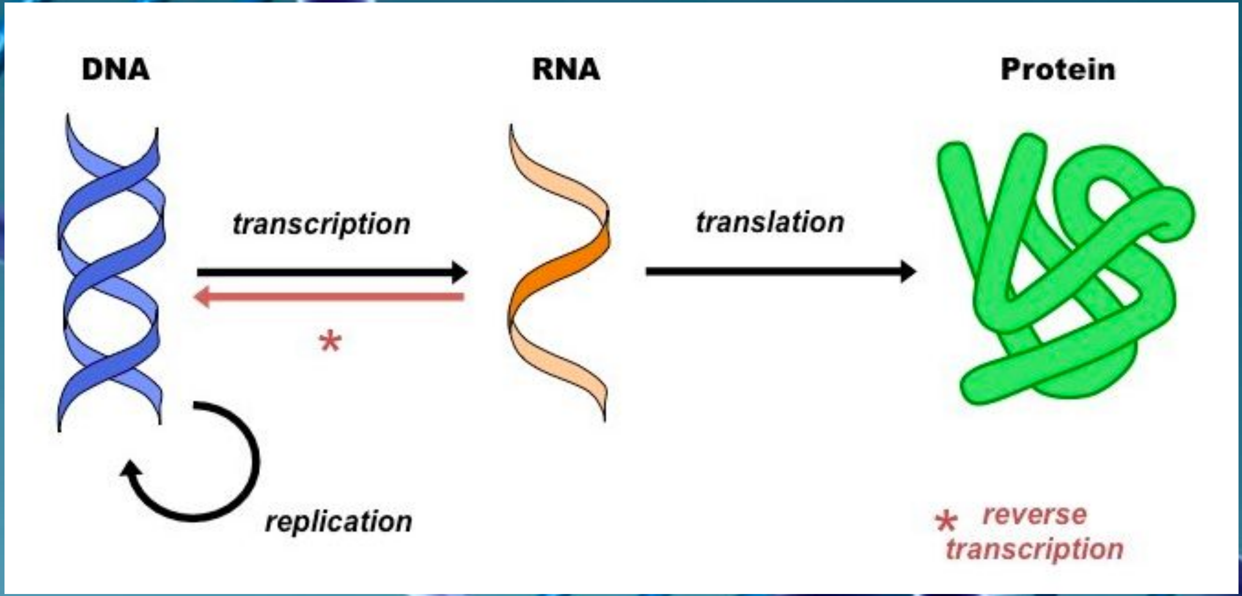
Part 4 of Jews in Science
May 23, 2021

What do these things have in common?

INNOCENCE PROJECT


All of these advancements were made possible by our understanding and manipulation of DNA

Deoxyribonucleic Acid (DNA)--Today we know a great deal about DNA's structure, how it encodes genetic information, how it is copied in the cell and how it can be manipulated in the laboratory.



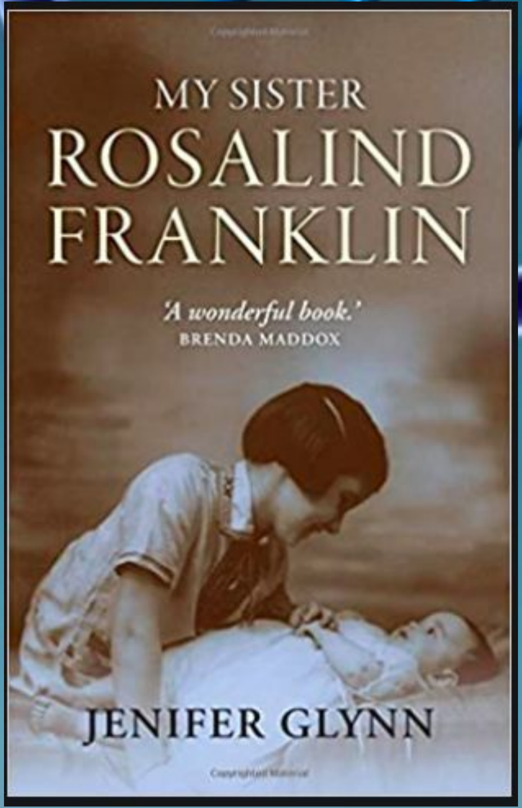
In the early 1950s, none of this was understood . . .

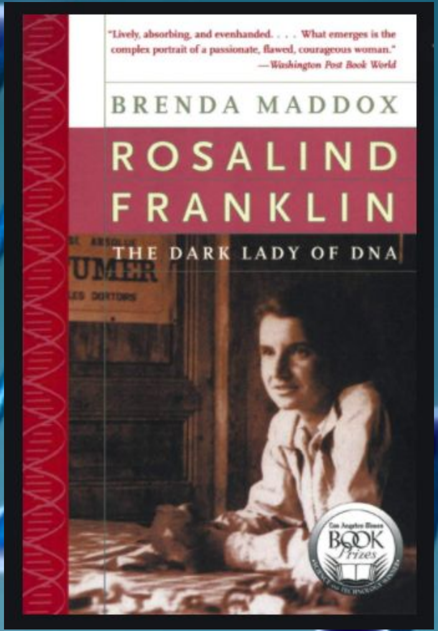
https://byjus.com/biology/central-dogma-inheritance-mechanism/

Rosalind Franklin’s work on DNA structure set the stage for a scientific revolution that continues to this day.

Sources


Meet the unsung heroine
behind the discovery
of DNA's double helix.
SECRET OF PHOTO 51


MY SISTER
ROSALIND
FRANKLIN
'A wonderful book.'
BRENDA MADDOX
JENIFER GLYNN


"Lively, absorbing, and evenhanded. . . . What emerges is the complex portrait of a passionate, flawed, courageous woman."
—Washington Post Book World
BRENDA MADDOX
ROSALIND
FRANKLIN
THE DARK LADY OF DNA

Early Life

Rosalind, second on right, holding her sister Jenifer's hand - who would follow her sister to Newnham College, Cambridge

Born July 25, 1950 in Notting Hill, London

Ellis and Muriel Franklin, parents

Ellis was well-known in the local Jewish community.

Her uncle, Herbert Samuel, was High Commissioner of Palestine and her aunt Helen Franklin, was heavily involved in Britain's women's suffrage movement.

https://www.bbc.com/news/uk-england-cambridgeshire-53514812

Education

Lindores Boarding School, St. Paul's Girls' School

Degree in physical chemistry, Newnham College, Cambridge in 1941

Her first job, in the lab of Robert Norrish, was not satisfying to Rosalind.

Franklin's love of intellectual arguments didn't sit well with Norrish.

Rosalind's parents were proud of Rosalind for going to college.

World War II

Franklin's PhD work at Cambridge centered on coal and other carbon-based minerals. She worked for the British Coal Utilization Research Association (BCURA). Of particular interest was how coal transitioned into different forms when heated. She also studied how pore sizes in coal changed while it was heated.

The results of this research had implications for war materiel such as gas masks and other purification filters, along with producing coke for making steel.

"Holes in Coal"

Franklin constructed the apparatus to the right for her experiments.

It was used to measure the volume of pores in coal by determining the pressure and volume changes of inert gas that could now penetrate the coal.

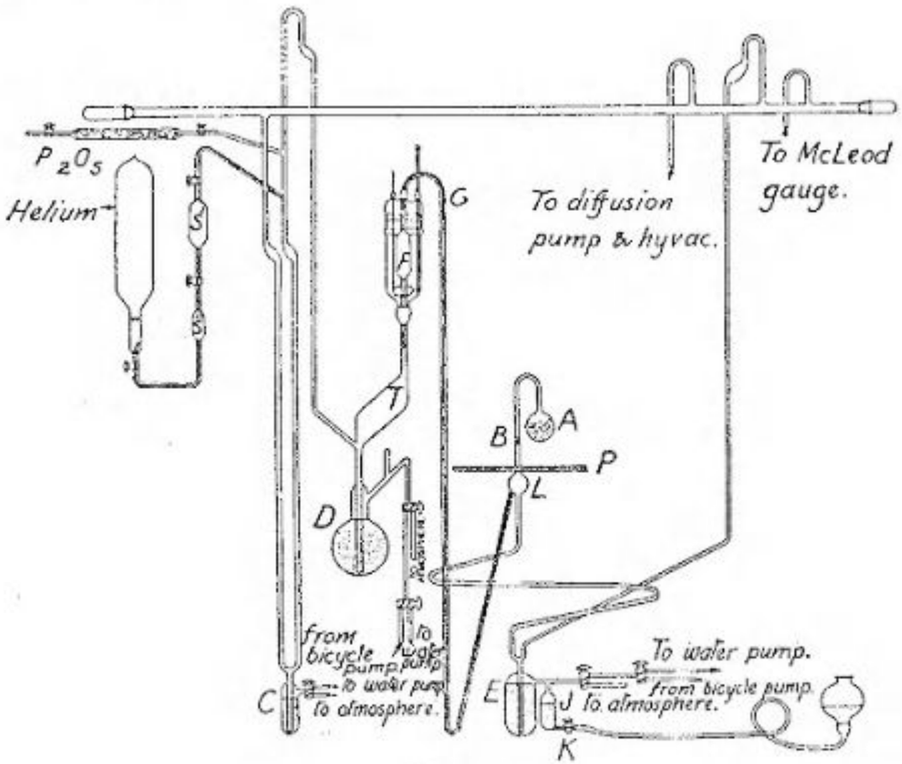


FIG. 2.

Franklin, Rosalind. "A Study of the Fine Structure of Carbonaceous Solids by Measurements of True and Apparent Densities: Part I. Coals." Transactions of the Faraday Society 45, (1949): 274-286.

Paris, France, 1947-1950

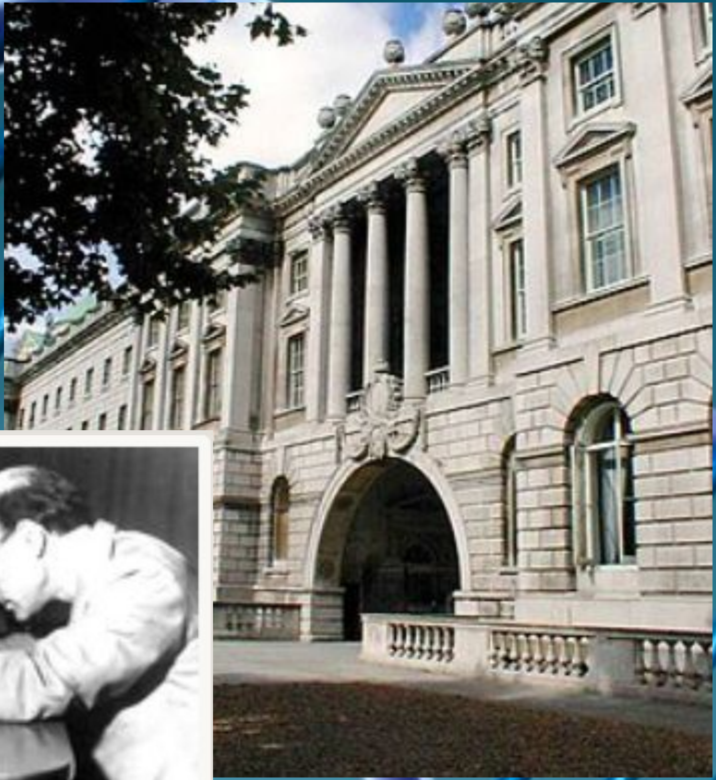
At Mering’s lab, Franklin learned the important scientific tool X-ray diffraction, which can be used to determine molecular structure with a high level of resolution and accuracy.

Working with Jacques Méring at the Laboratoire Central des Services Chimiques de l’État between 1947 and 1950

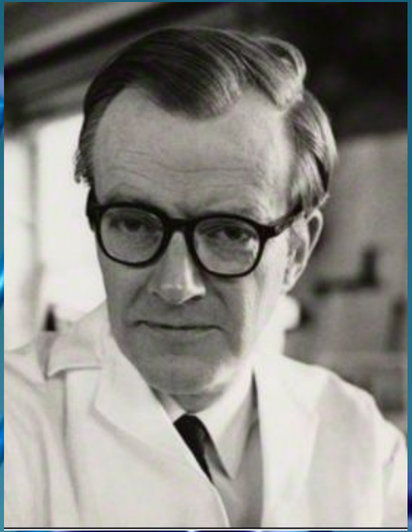
Life on the Continent

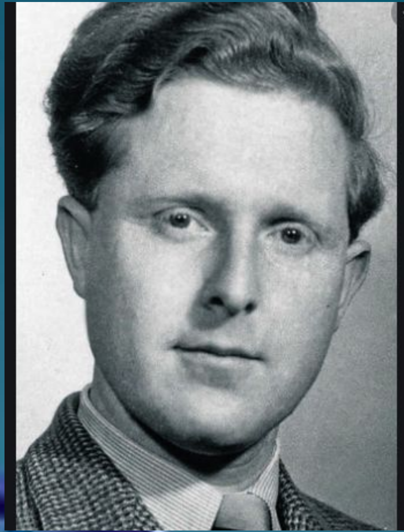
Vacation in Tuscany, photo taken by Vittorio Luzzati

King’s College (1951-1953)



Sir John Randall, Biophysics Unit





Maurice Wilkins and Raymond Gosling

King’s College

While direct and sometimes abrasive in the lab, Franklin had a full social life outside of her immediate work surroundings. She enjoyed the mixed Committee Dining Room at King’s but chafed at the prohibition against women in the more formal Senior Common Room.

Note: image is from Oxford, not Cambridge

Watson and Crick

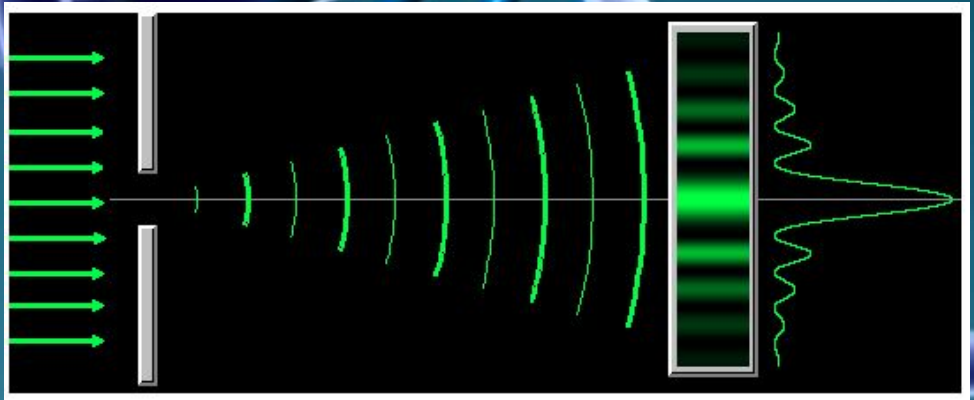
Researchers at the Cavendish Laboratories

Constructed models to try and understand the structure of DNA

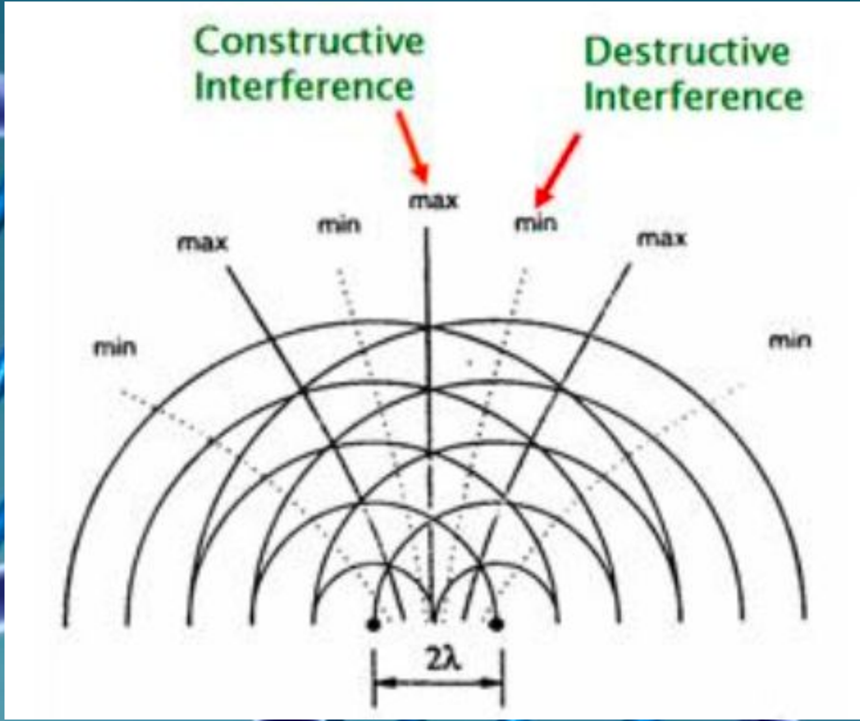
Were aware of Franklin’s work and attended her lectures

At one point were told to cease working on DNA by Lawrence Bragg, but later resumed when Linus Pauling began studying it

Principles of Diffraction



As light waves pass through a small opening (slit), it spreads out. According to Huygens principle, each point in the opening acts like a generator of small wavelets of light. These waves interfere with each other or reinforce each other to produce a pattern at a certain distance from the opening.



How does X-ray crystallography/diffraction work?

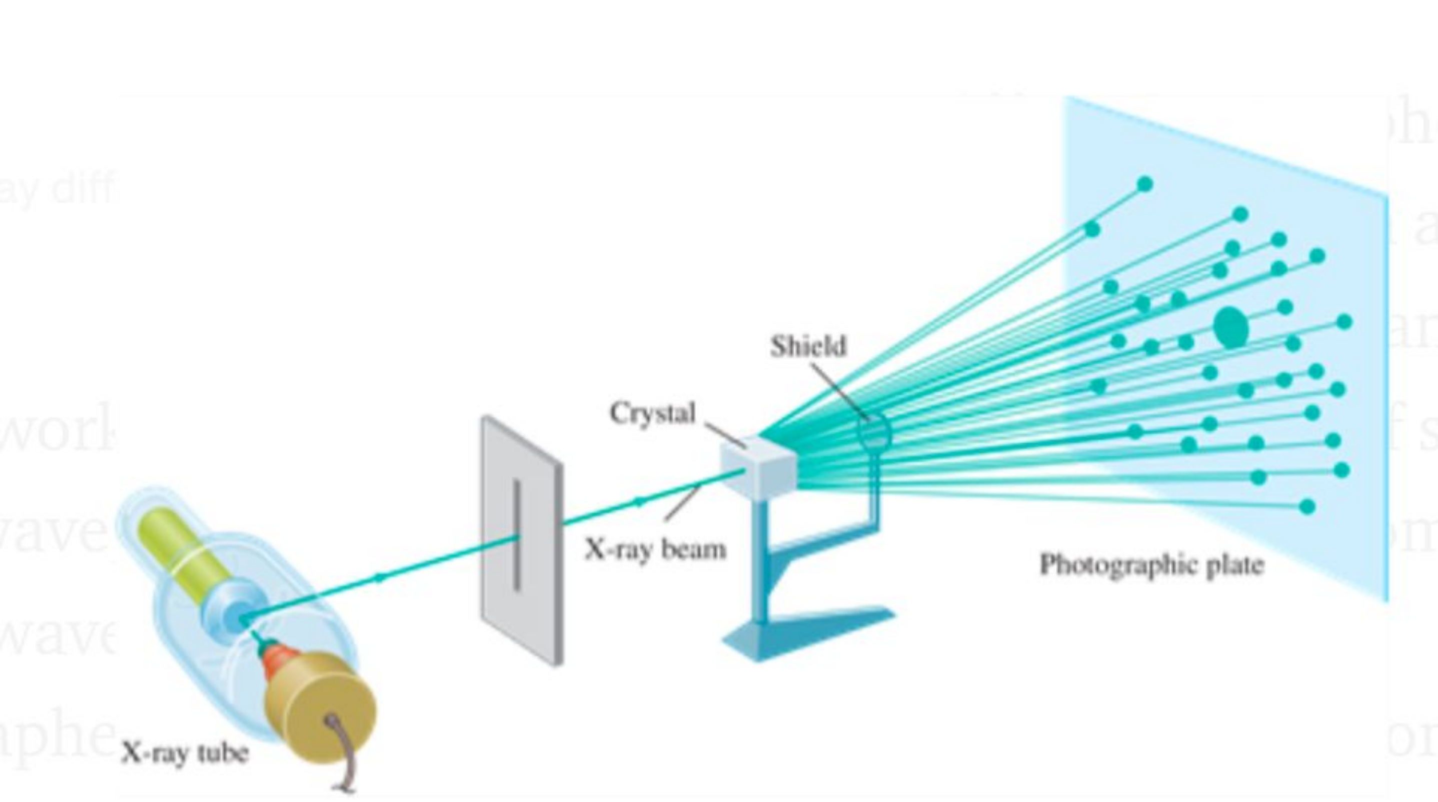
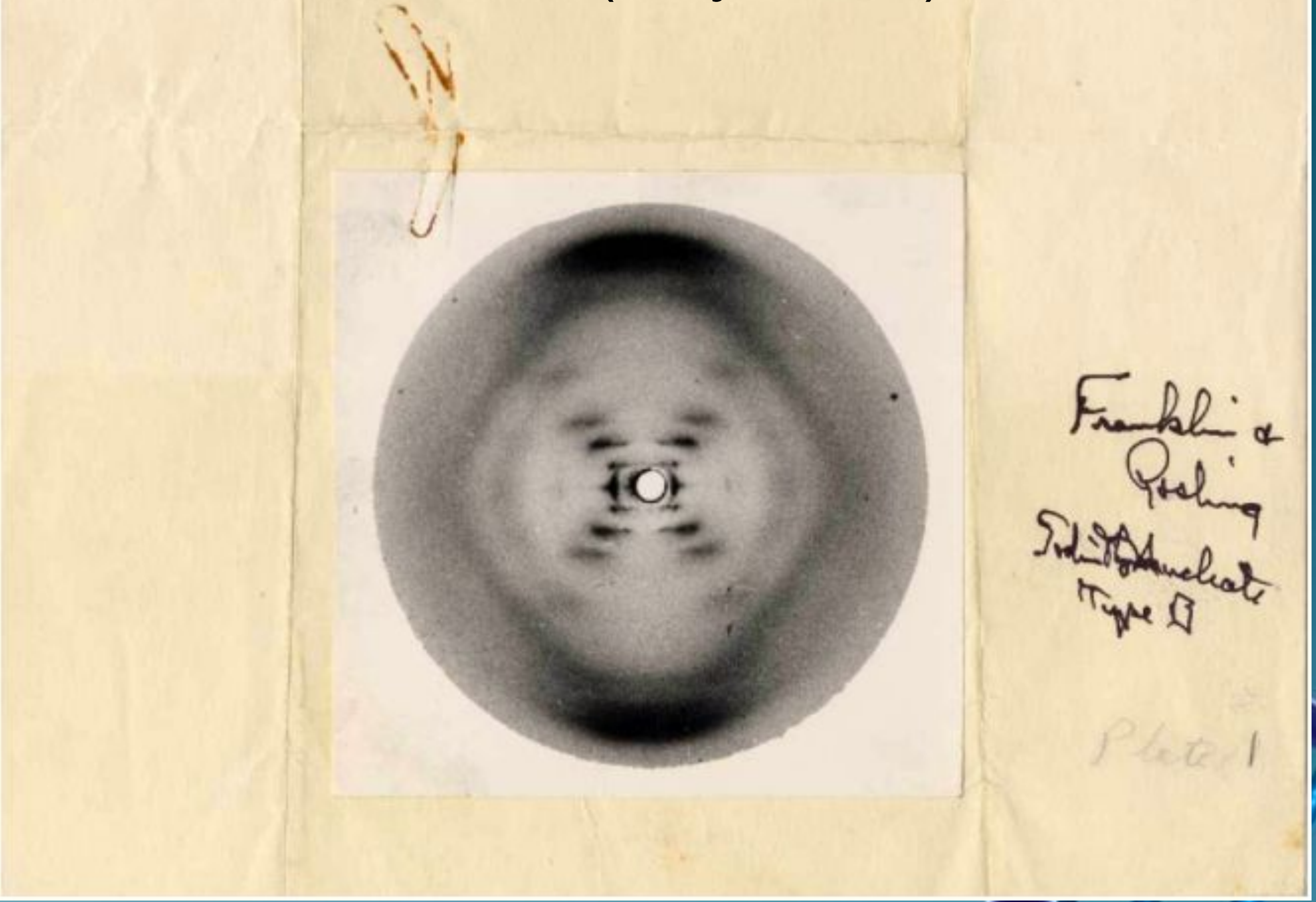
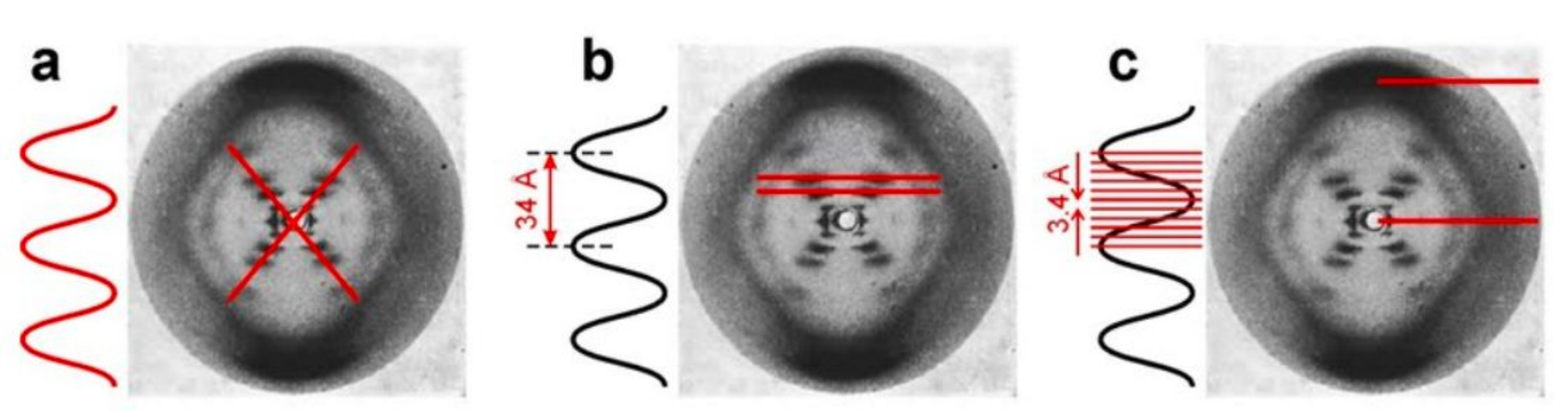


Photo 51 (May, 1952)

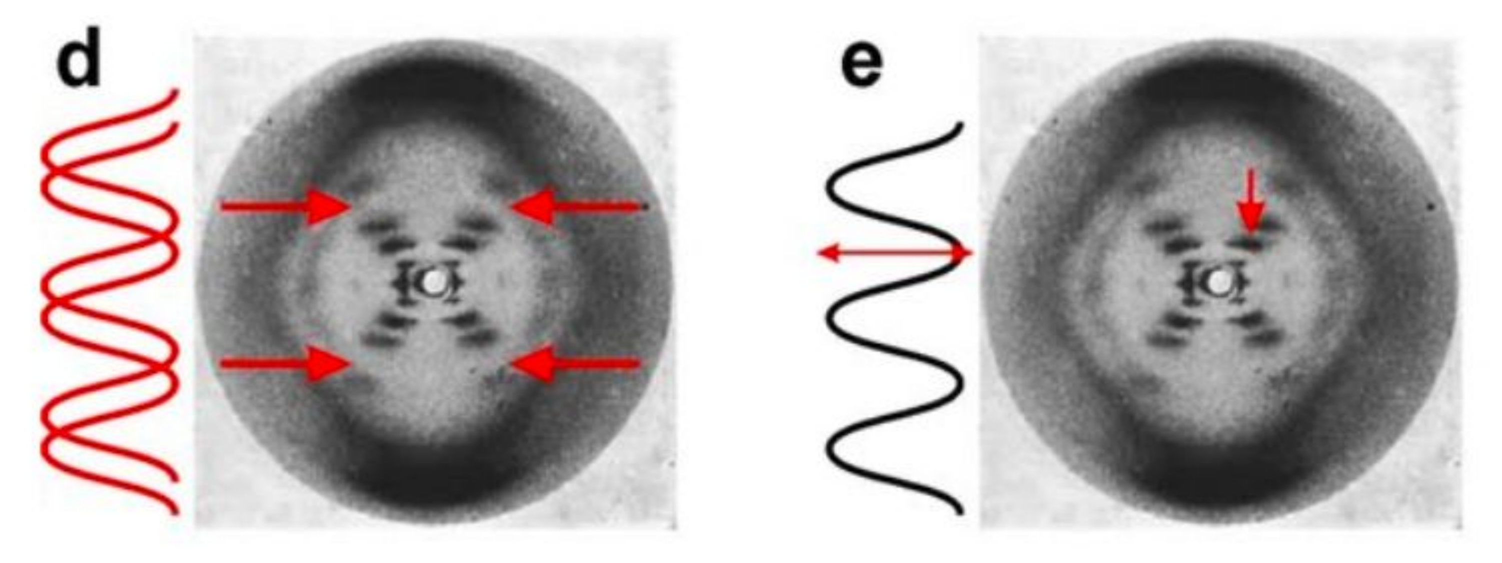


Interpreting Photo 51



Latychevskaia

Interpreting Photo 51



Latychevskaia

How did Watson and Crick get photo 51?

In a footnote to a 1954 paper, Crick and Watson wrote, “we wish to point out that without this data [King's] the formulation of our structure would have been most unlikely, if not impossible.”

Wilkins showed the X ray photo to Watson during a visit to King’s College.

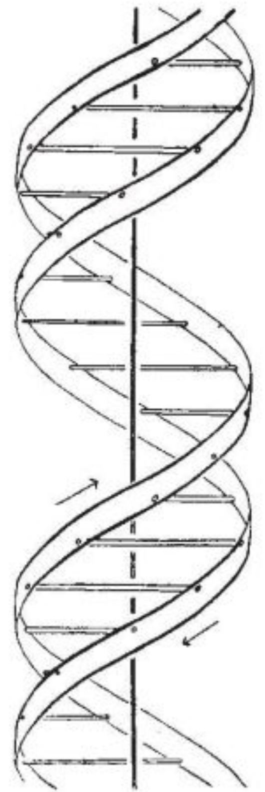
MRC report detailing Franklin and Gosling’s work was given to Max Perutz at Cambridge, then to Bragg, then to Watson and Crick at Cavendish.

Was the data really stolen?

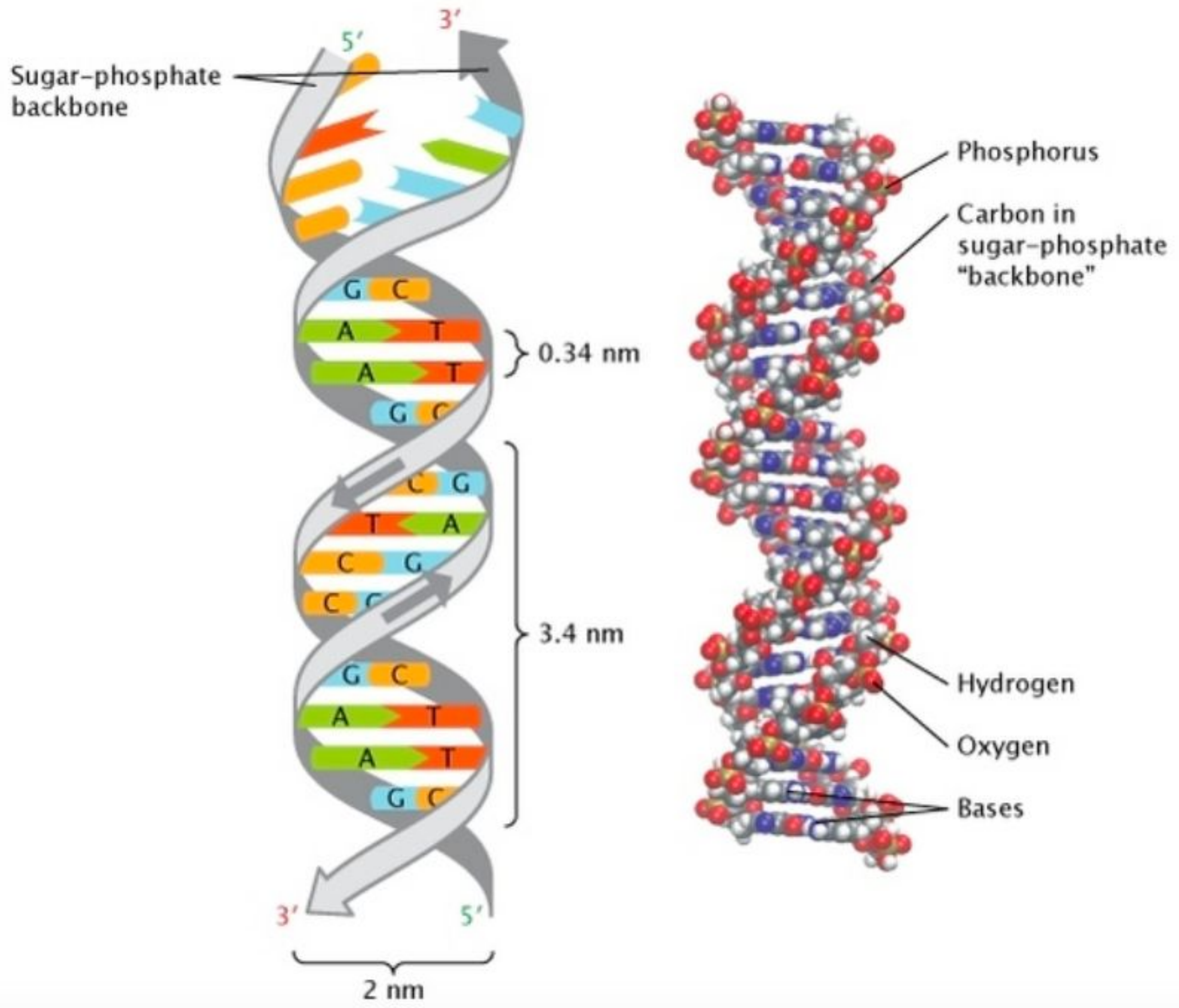
(Cobb)

Watson and Crick's model of DNA

Watson, J.D. and Crick, F.H.C. (1953). Molecular Structure of Nucleic Acids. Nature (171): 737-738



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


5′
3′
Sugar–phosphate backbone
G C
A T
A T
G C
0.34 nm
C G
T A
C G
C G
G C
A T
A T
G C
3.4 nm
3′
5′
2 nm
Phosphorus
Carbon in sugar–phosphate "backbone"
Hydrogen
Oxygen
Bases

Franklin, R.E., and Gosling, R.G. (1953) Molecular Configuration in Sodium Thymonucleate. Nature 171: 740-741

We wish to thank Prof. J. T. Randall for encouragement; Profs. E. Chargaff, R. Signer, J. A. V. Butler and Drs. J. D. Watson, J. D. Smith, L. Hamilton, J. C. White and G. R. Wyatt for supplying material without which this work would have been impossible; also Drs. J. D. Watson and Mr. F. H. C. Crick for stimulation, and our colleagues R. E. Franklin, R. G. Gosling, G. L. Brown and W. E. Seeds for discussion. One of us (H. R. W.) wishes to acknowledge the award of a University of Wales Fellowship.

M. H. F. WILKINS
Medical Research Council Biophysics Research Unit,

A. R. STOKES
H. R. WILSON
Wheatstone Physics Laboratory,
King's College, London.
April 2.

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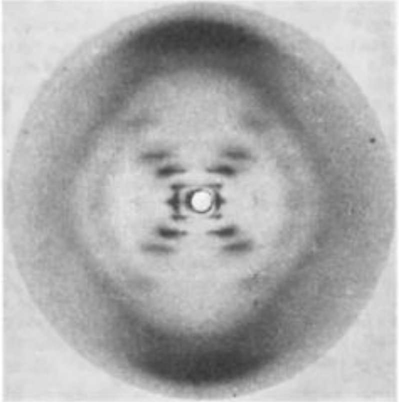
[2] Riley, D. P., and Oster, G., *Biochim. et Biophys. Acta*, 7, 526 (1951).
[3] Wilkins, M. H. F., Gosling, R. G., and Seeds, W. E., *Nature*, 167, 759 (1951).
[4] Astbury, W. T., and Bell, F. O., Cold Spring Harb. Symp. Quant. Biol., 6, 109 (1938).
[5] Cochran, W., Crick, F. H. C., and Vand, V., *Acta Cryst.*, 5, 581 (1952).
[6] Wilkins, M. H. F., and Randall, J. T., *Biochim. et Biophys. Acta*, 10, 192 (1953).

Molecular Configuration in Sodium Thymonucleate

SODIUM thymonucleate fibres give two distinct types of X-ray diagram. The first corresponds to a crystalline form, structure *A*, obtained at about 75 per cent relative humidity; a study of this is described in detail elsewhere[1]. At higher humidities a different structure, structure *B*, showing a lower degree of order, appears and persists over a wide range of ambient humidity. The change from *A* to *B* is reversible. The water content of structure *B* fibres which undergo this reversible change may vary from 40–50 per cent to several hundred per cent of the dry weight. Moreover, some fibres never show structure *A*, and in these structure *B* can be obtained with an even lower water content.



Sodium deoxyribose nucleate from calf thymus. Structure *B*

molecules, each unit being shielded by a sheath of water. Each unit is then free to take up its least-energy configuration independently of its neighbours and, in view of the nature of the long-chain molecules involved, it is highly likely that the general form will be helical[3]. If we adopt the hypothesis of a helical structure, it is immediately possible, from the X-ray diagram of structure *B*, to make certain deductions as to the nature and dimensions of the helix.

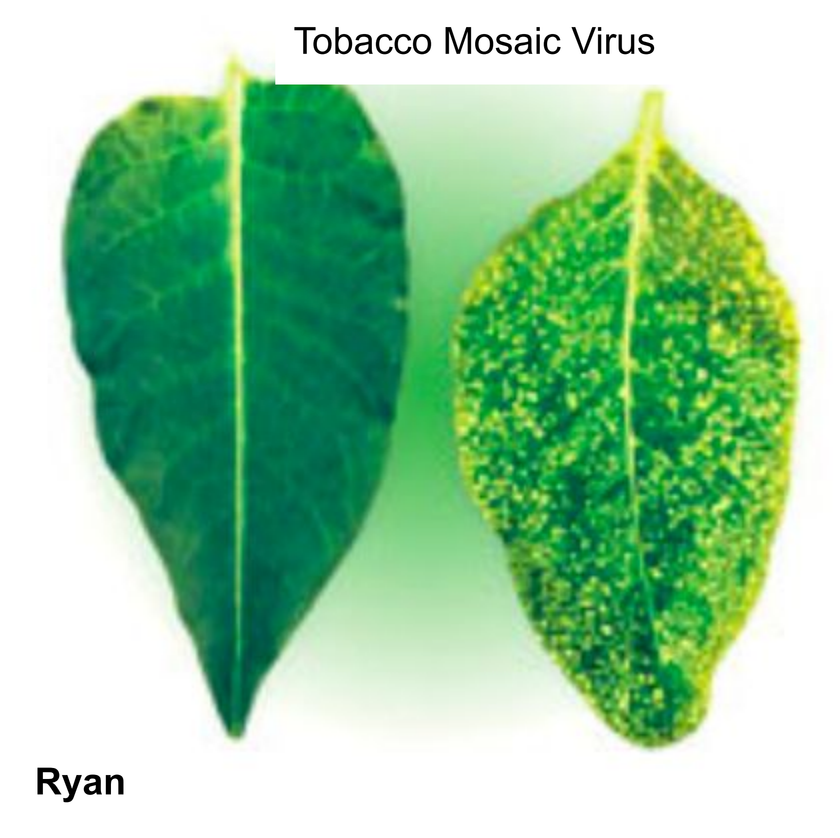
The innermost maxima on the first, second, third and fifth layer lines lie approximately on straight lines radiating from the origin. For a smooth single-strand helix the structure factor on the *n*th layer line is given by:

$$F_n = J_n(2\pi rR) \exp i\,n(\psi + \tfrac{1}{2}\pi),$$

where $J_n(u)$ is the *n*th-order Bessel function of *u*, *r* is the radius of the helix, and *R* and ψ are the radial and azimuthal co-ordinates in reciprocal space[2]; this expression leads to an approximately linear array of intensity maxima of the type observed, corresponding to the first maxima in the functions J_1, J_2, J_3, etc.

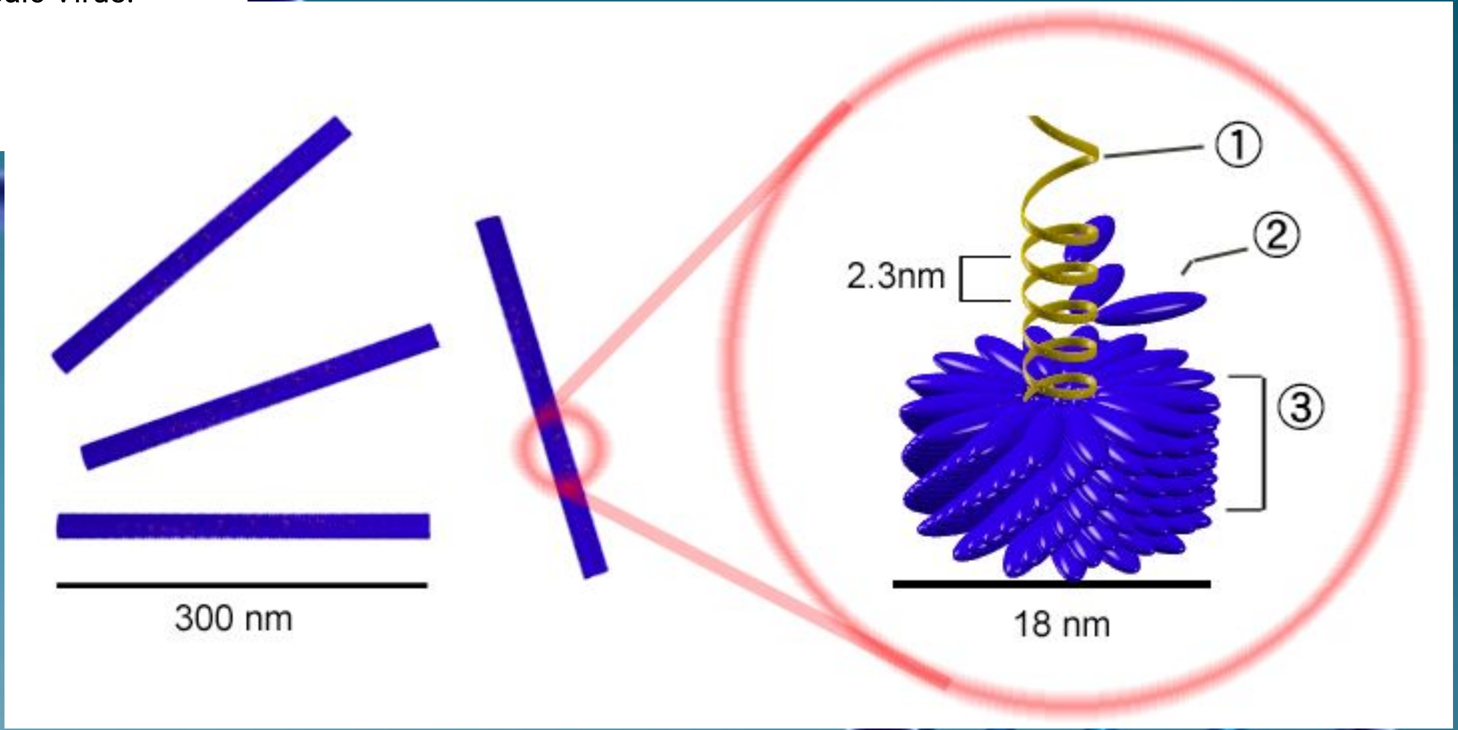
If, instead of a smooth helix, we consider a series

1953-1958 Birkbeck College
Moving on to study viruses



Accomplishments at Birkbeck

ROSALIND E. FRANKLIN (1955).
Structure of Tobacco Mosaic Virus.
Nature 175: 379-381.

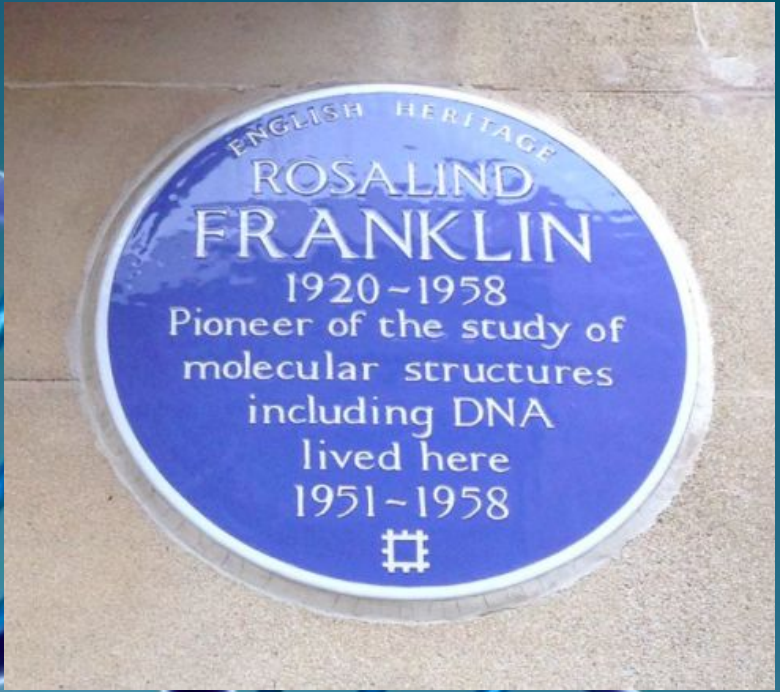


Final Years

While traveling in the United States in 1956, Franklin took ill. This was later diagnosed with ovarian cancer. Rosalind Franklin died in 1958, after a brief remission and relapse.

Four years later, in 1962 Watson and Crick were awarded the Nobel Prize, along with Maurice Wilkins.

Had she lived, she would have been most deserving of a share in the Nobel Prize.



Scientific Legacy

During her lifetime Franklin was recognized as a leader in the field of carbon chemistry and virus structure.

She was the author of 45 papers (19 on coal, 5 on DNA, and 17 on viruses).

Franklin's X-ray diffraction data were absolutely instrumental in the elucidation of DNA's double helical structure.

In 2000, officials at King's College, London named their new building the Franklin-Wilkins building, in honor of their two main DNA researchers.

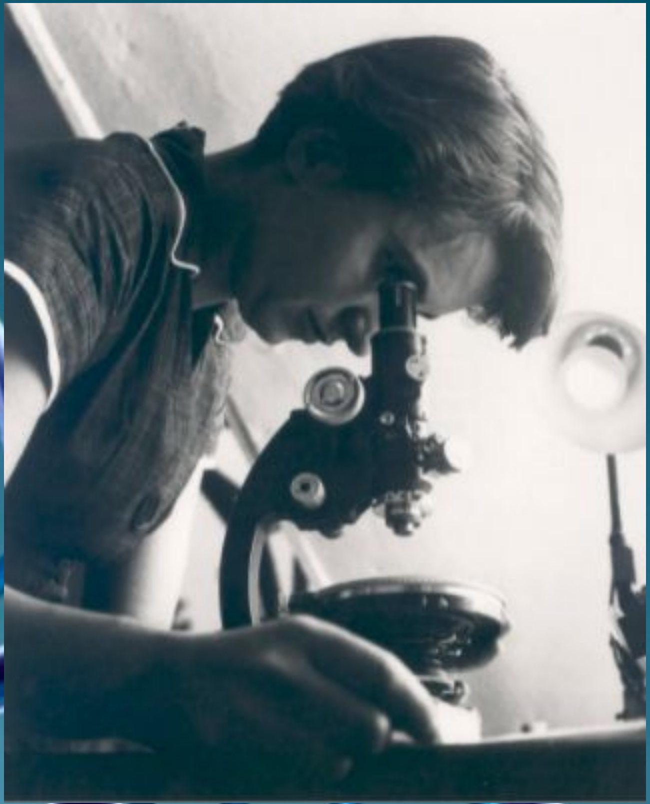
Beliefs and values

Rosalind Franklin identified as Jewish, and Jewish causes became more important to her during the war.

Her upbringing stressed service to humanity, and throughout her life it was most important to Rosalind that she do useful work.

She did express an interest in equality between the sexes (Elkin)

Her experience growing up with refugees from Nazi Germany taught her the dangers of fascism. Throughout her time in France, Rosalind engaged in robust political discussions.

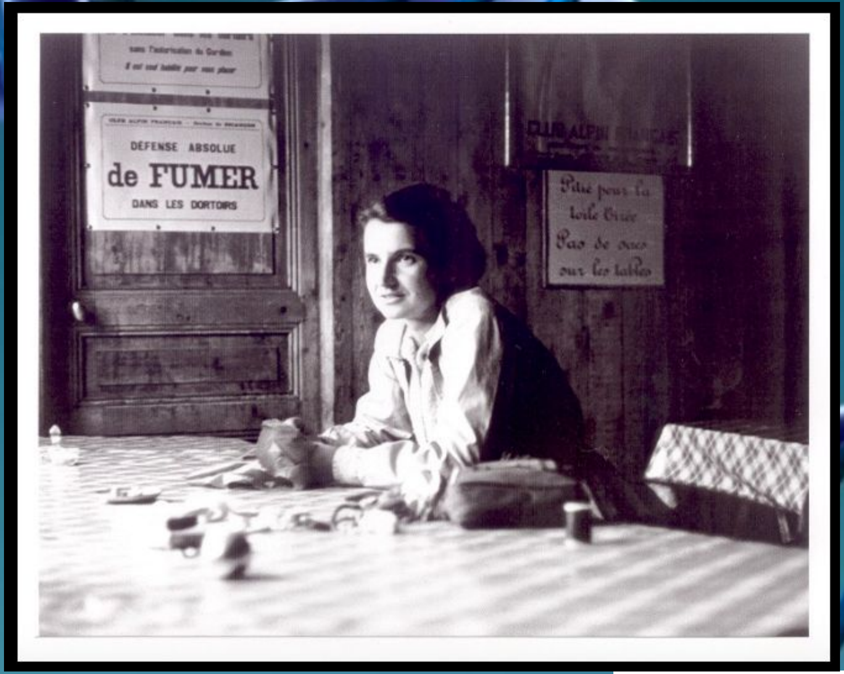


Did Rosalind hold particular religious views?

"Science and everyday life cannot and should not be separated. Science, for me, gives a partial explanation of life. In so far as it goes, it is based on fact, experience, and experiment. . . . I agree that faith is essential to success in life, but I do not accept your definition of faith, i.e., belief in life after death. In my view, all that is necessary for faith is the belief that by doing our best we shall come nearer to success and that success in our aims (the improvement of the lot of mankind, present and future) is worth attaining. Anyone able to believe in all that religion implies must have such faith, but I maintain that faith in this world is perfectly possible without faith in another world. . .

. . .It has just occurred to me that you may raise the question of a creator. A creator of what? I cannot argue biologically, as that is not my field."

– Rosalind Franklin in a letter to her father, 1940



Historical Legacy

In the words of her sister, she is neither an “argumentative swot . . a downtrodden woman scientist, or . . .a triumphant heroine in a man’s world. . . She was simply a very good scientist with an ambition. . . to be a Fellow of the Royal Society before she was forty.”

Additional Sources

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