

# **Déchiffrements**

***Hiéroglyphes et  
Structure de l'ADN***

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FUNDP, Namur**

# **Une courte histoire du temps**

- **Depuis 200 ans :**  
**Les étapes principales qui ont conduit à la découverte de la structure de l'ADN, vues par un physicien**
- **Depuis 50 ans :**  
**Le code génétique et le déchiffrement des gènes**

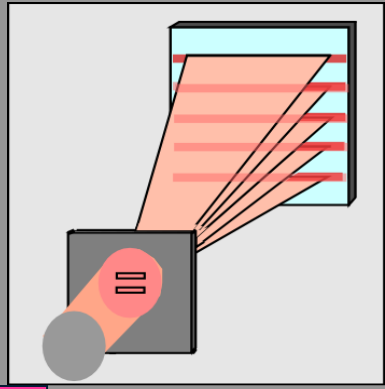
# 50 years ago

1953 : yet another wonder year

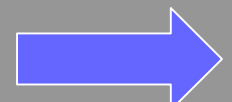
- \* 1st H-Bomb
- \* Stalin death
- \* Cuban revolution
- \* End of Korean war
- \* The Rosenbergs

- \* Phase-contrast Microscopy
- \* Miller-Urey Experiment
- \* Perutz Isomorph. Replacement
- \* **DNA Structure**

803

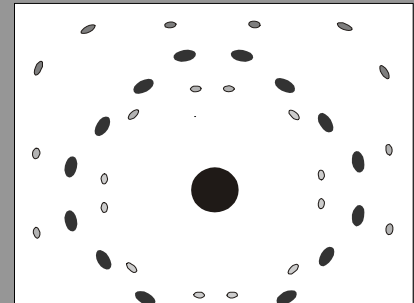


Young Diff.

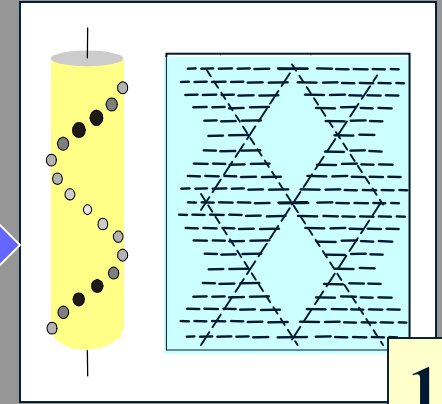


1896

Röntgen-Von Laue-Bragg(s)

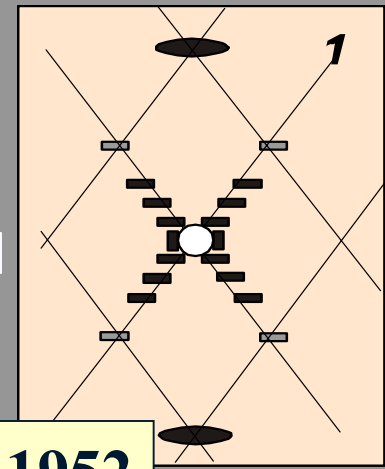
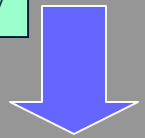


1912-14



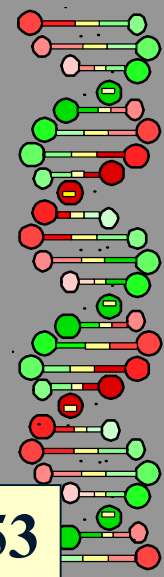
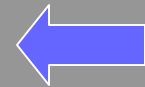
1952

CCV Theory



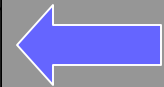
1952

Franklin



1953

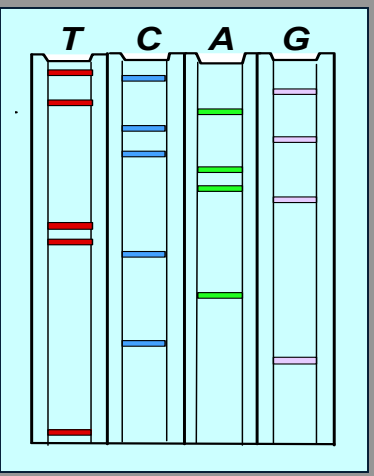
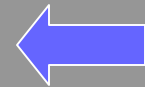
Watson-Crick



2	U	C	A	G	3
1	U				U C A G
	C	Pro			U C A G
	A	Met			U C A G
	G				U C A G

1961-66

Triplet Code



GCACCTTGAACGCATGCT

Sanger-Gilbert

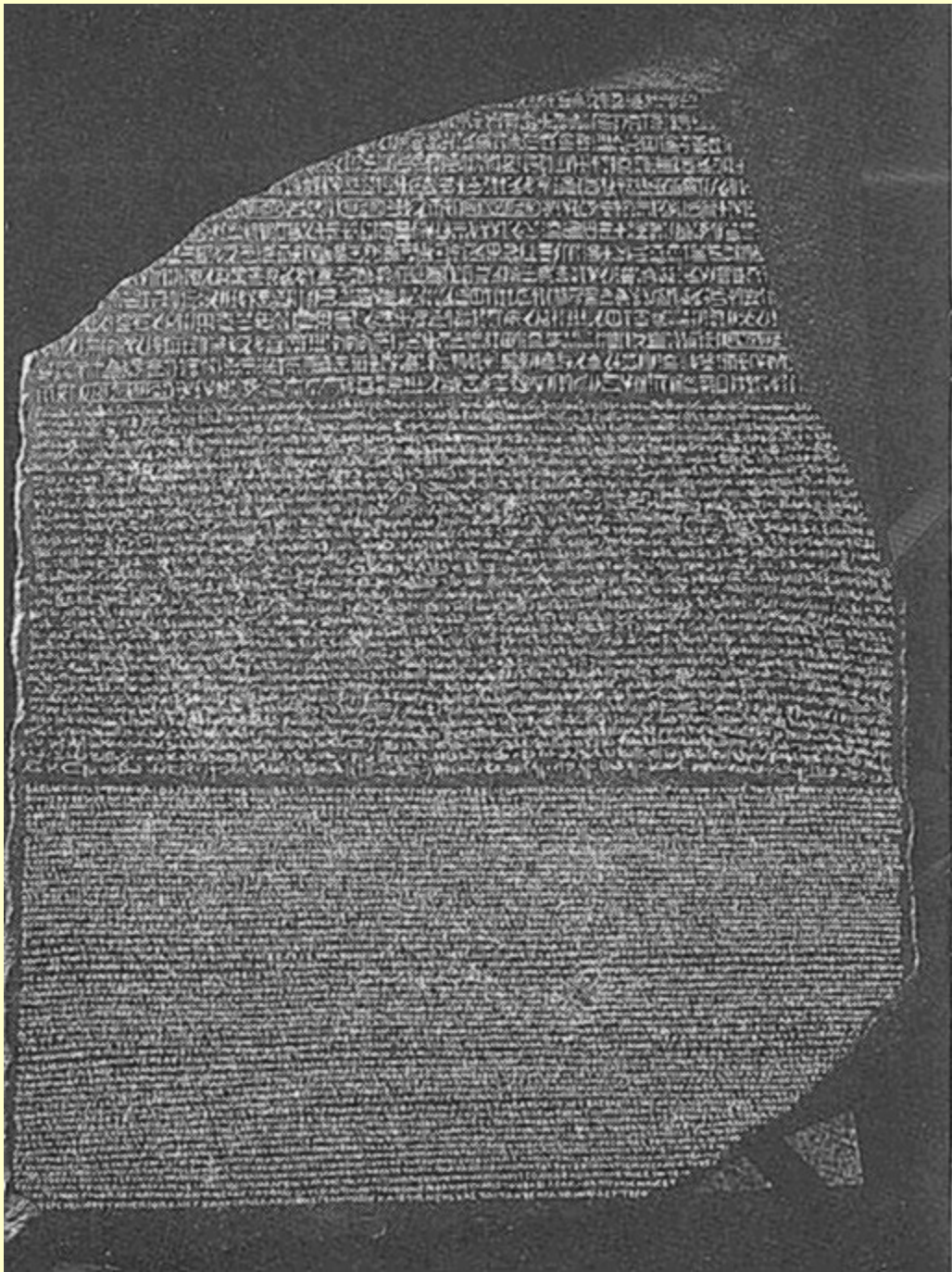
1975-77



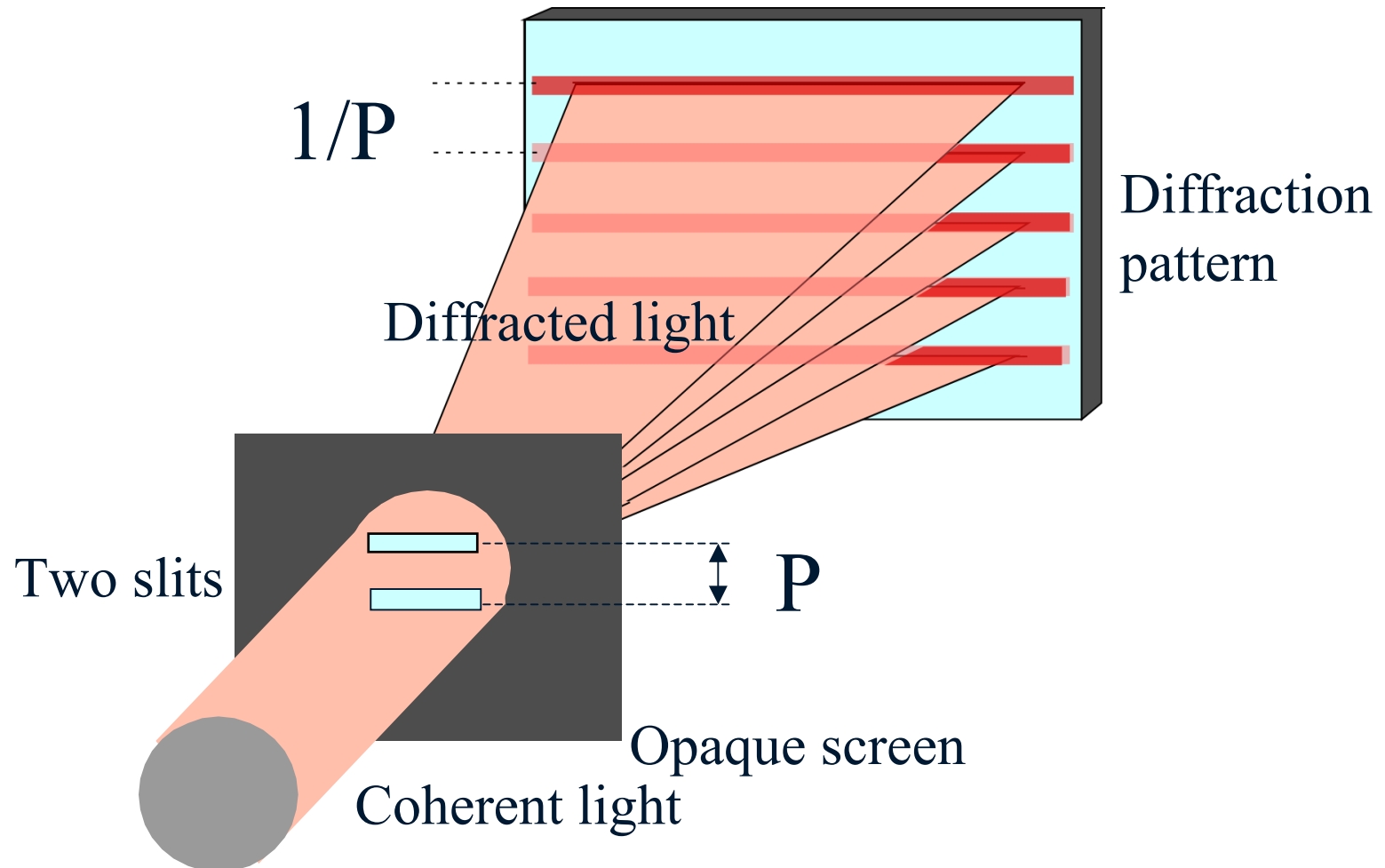
Recombinant – Cloning – PCR – GENOMES - Proteomes

2003

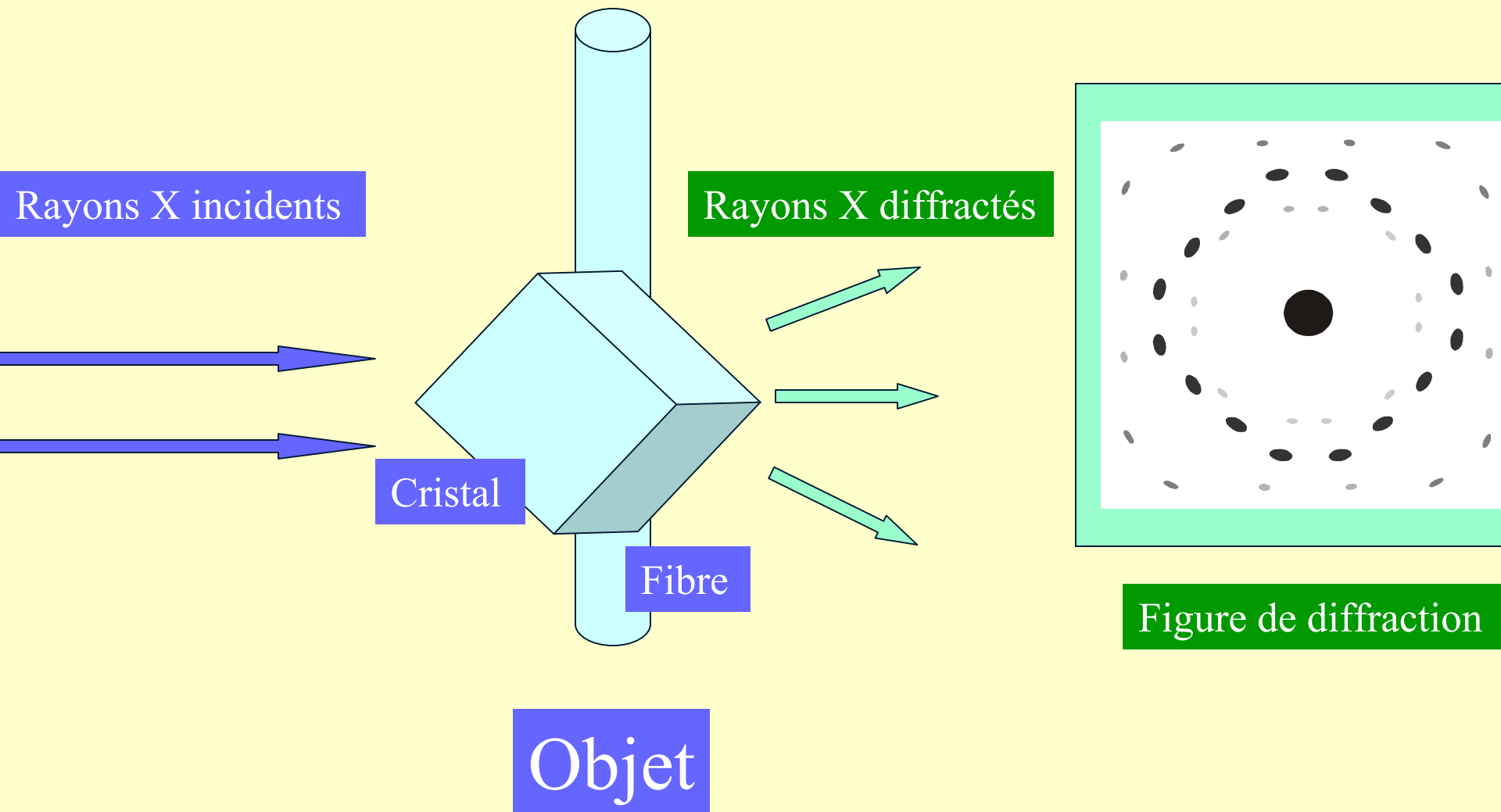
# The Rosetta Stone



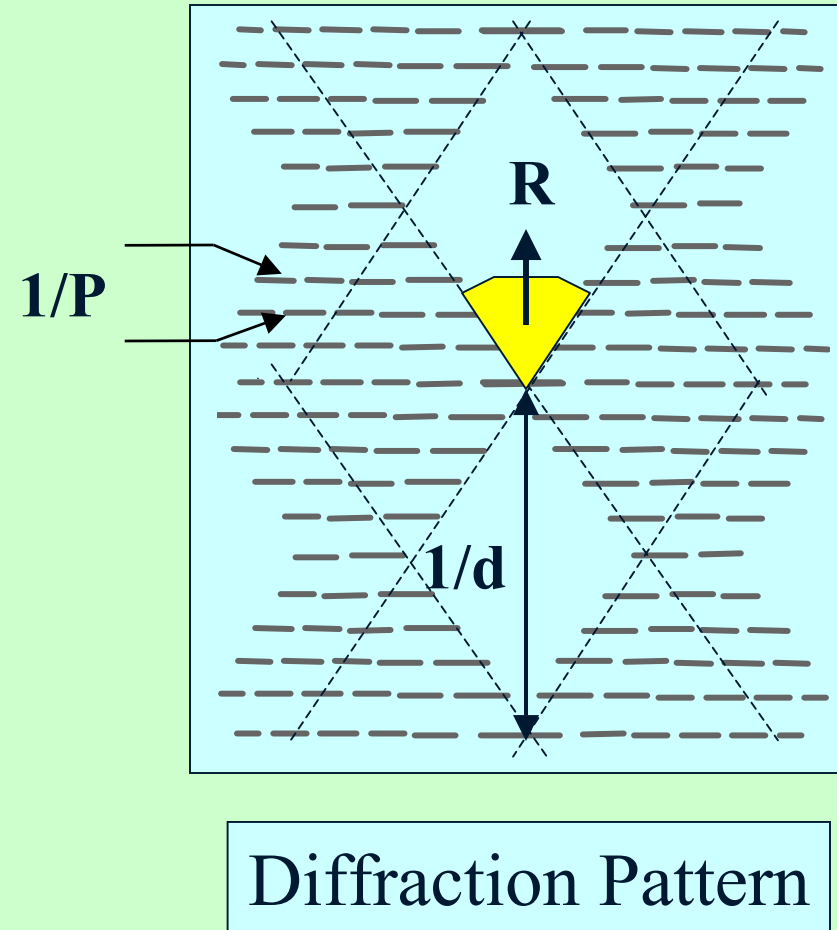
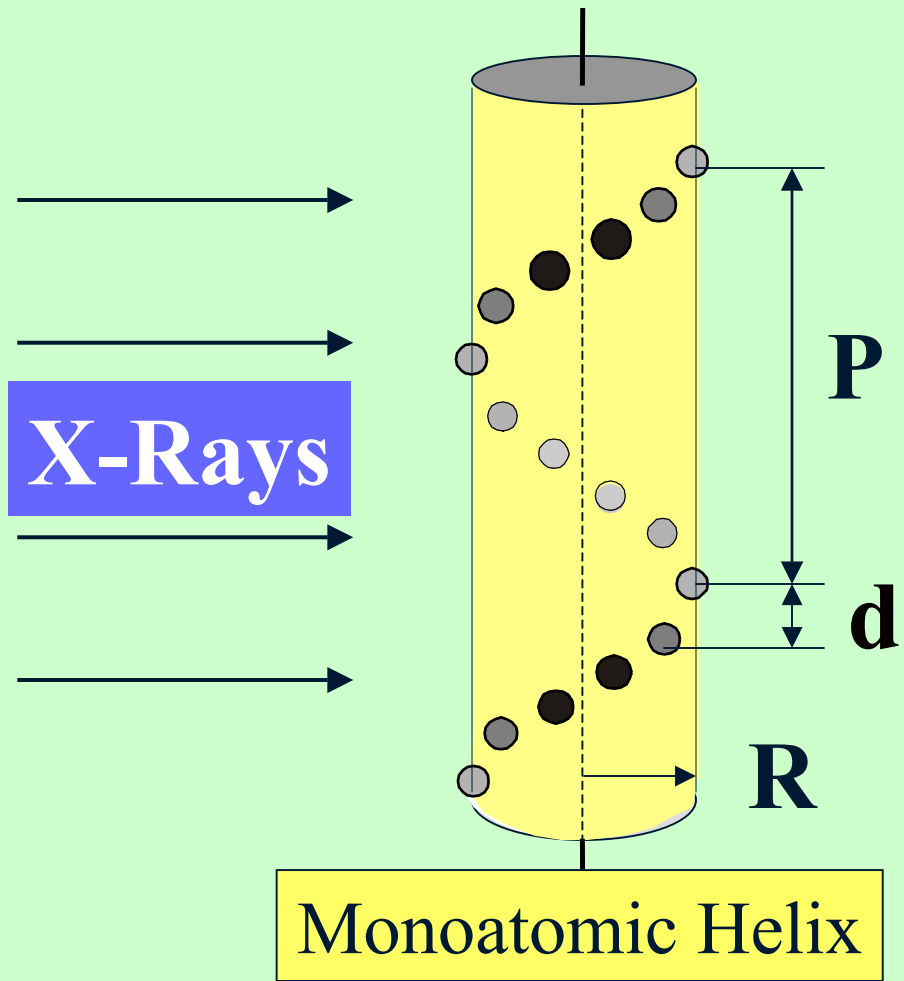
# Young diffraction experiment



# Diffraction des Rayons X



# Cochran, Crick, Vand (CCV) Theory

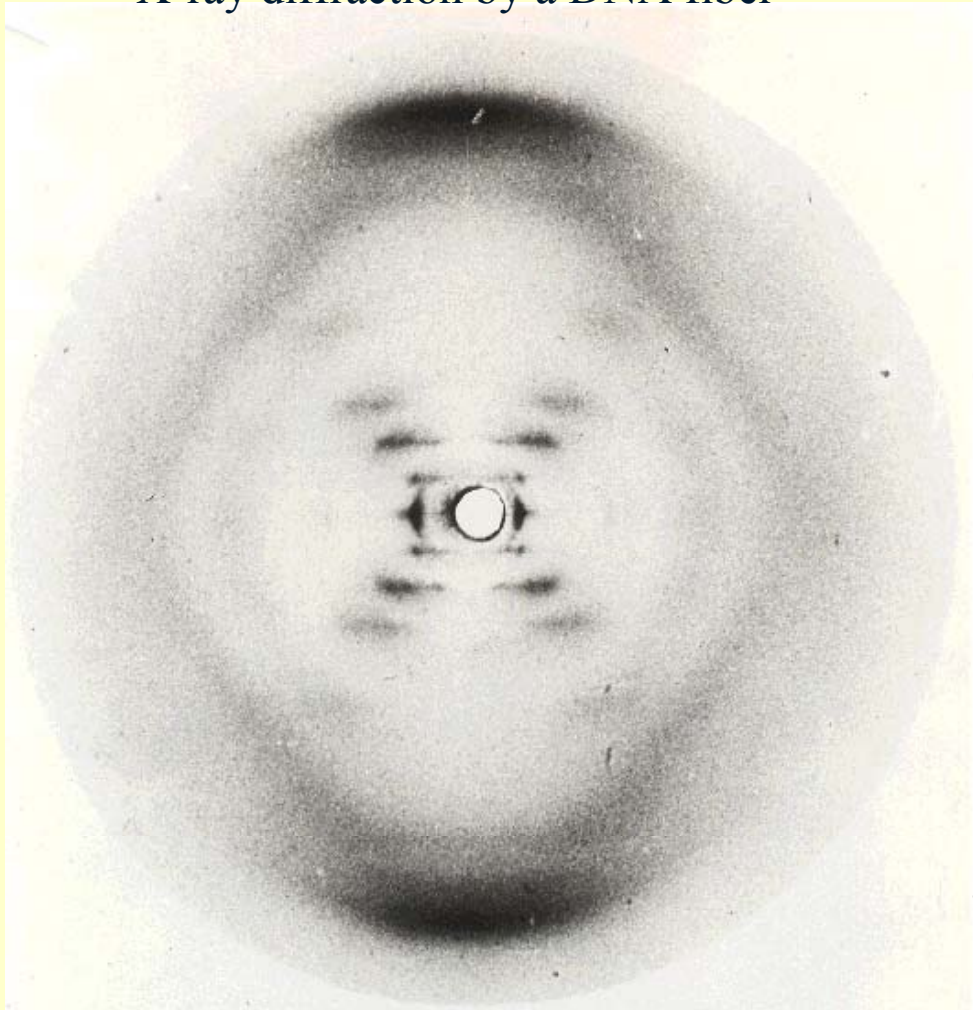




Rosalind Franklin

# The Rosetta Stone

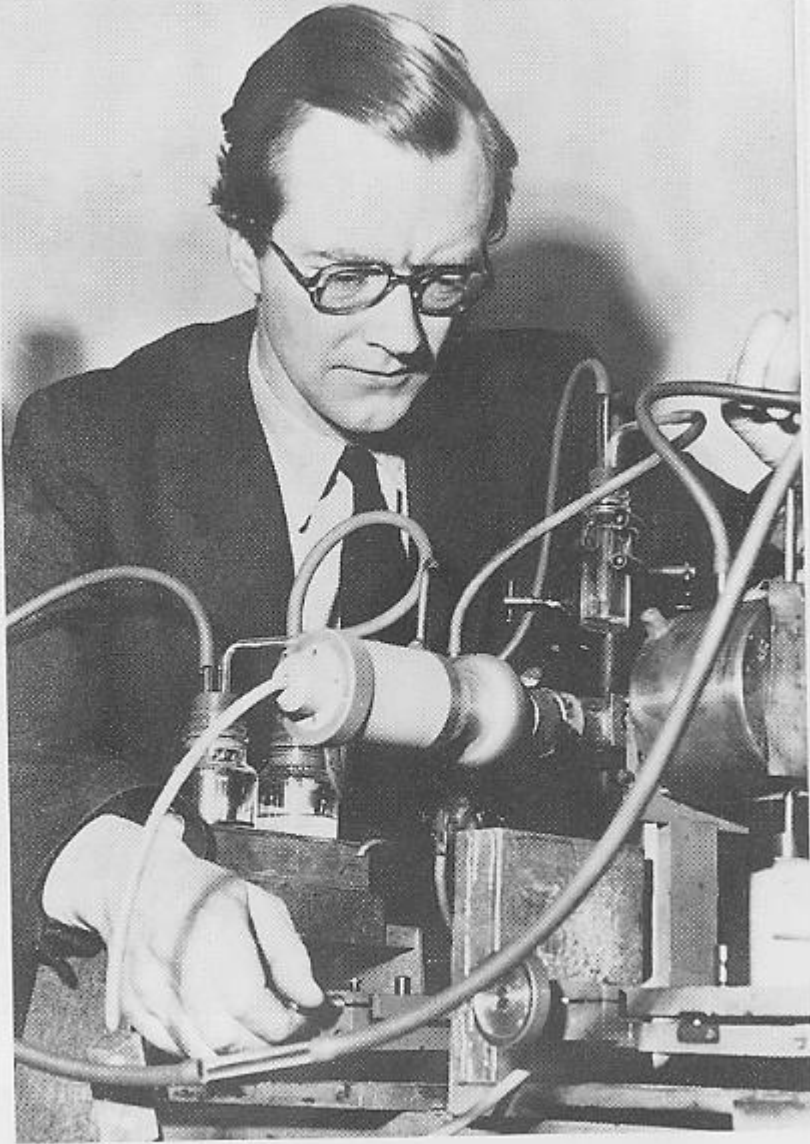
X-ray diffraction by a DNA fiber



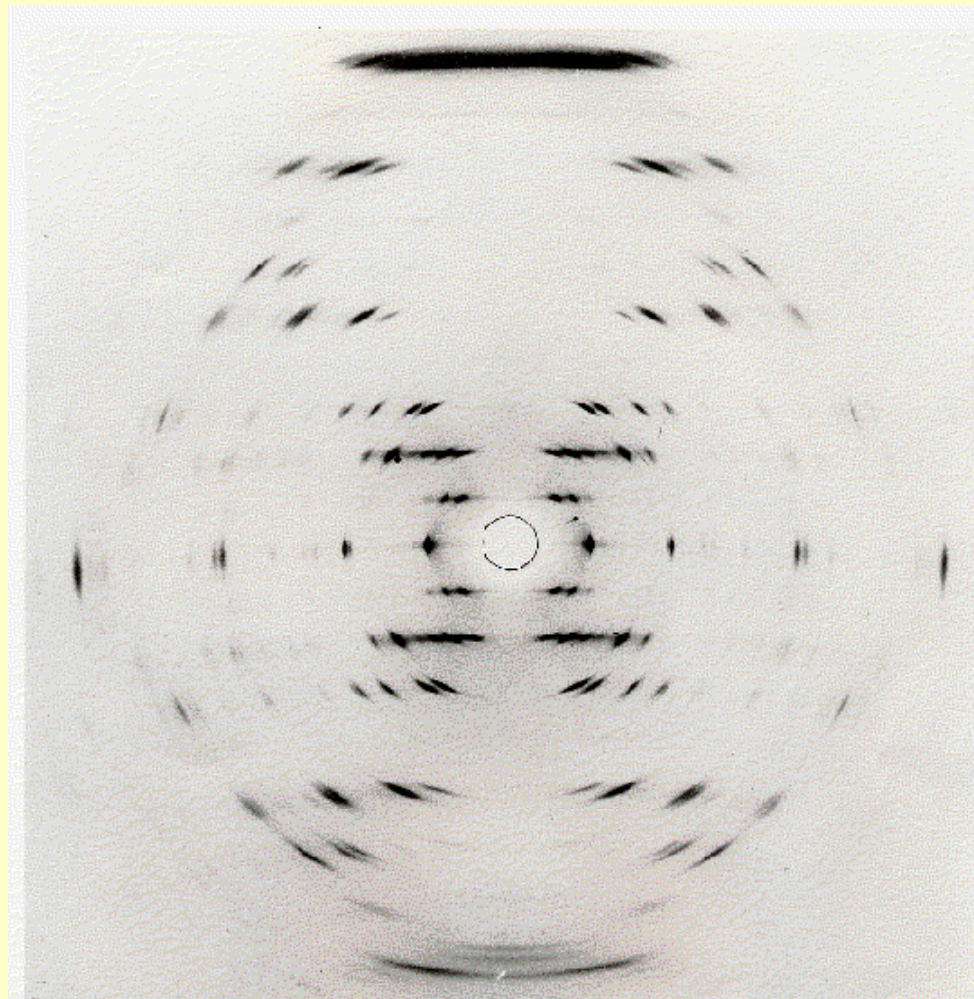
Too deep for tears: Rosalind in a pensive mood.

*« Her photographs are among the most beautiful X-ray photographs of any substance ever taken. » J.D. Bernal*

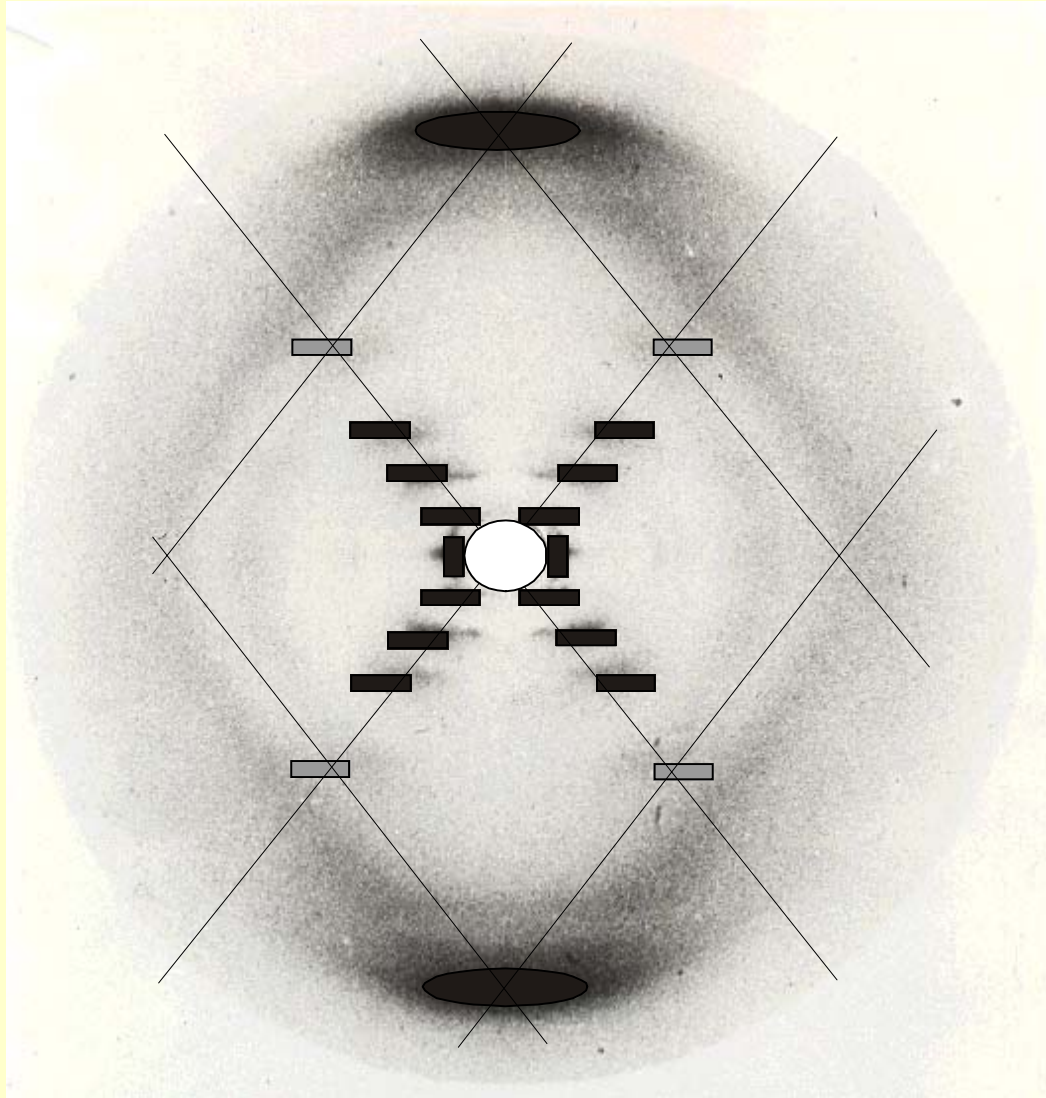
# Wilkins 1957



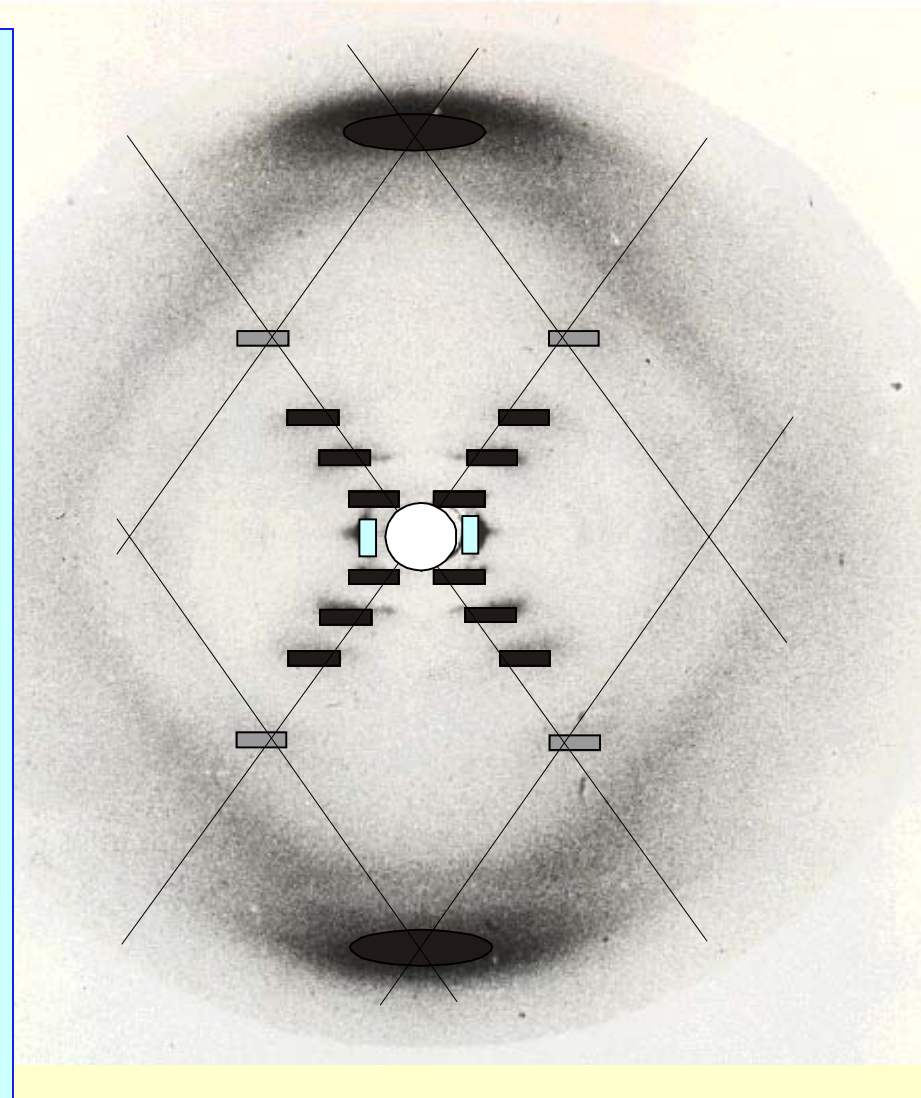
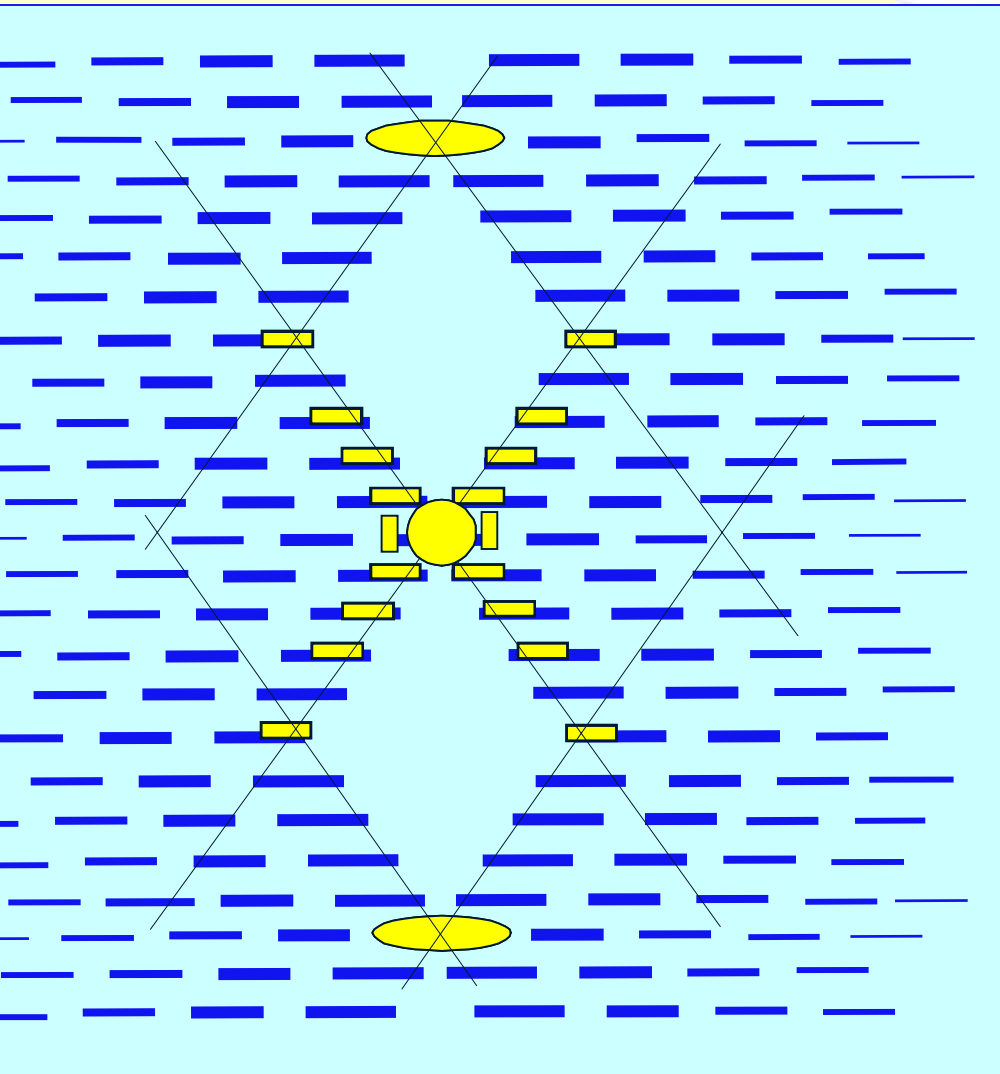
Maurice Wilkins.



# The revelation



# The revelation

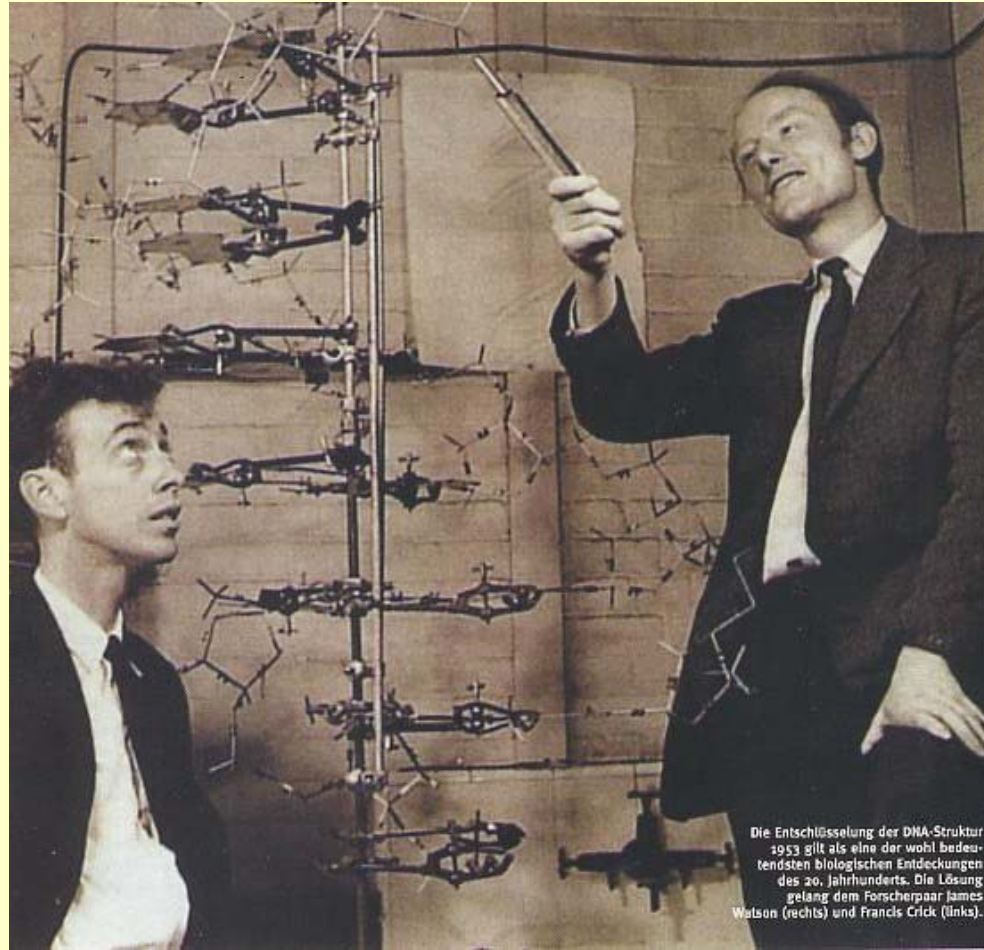


*The instant I saw the picture, my mouth fell open and my pulse began to race*  
J. Watson, from « The Double Helix »

# Watson

# 1953

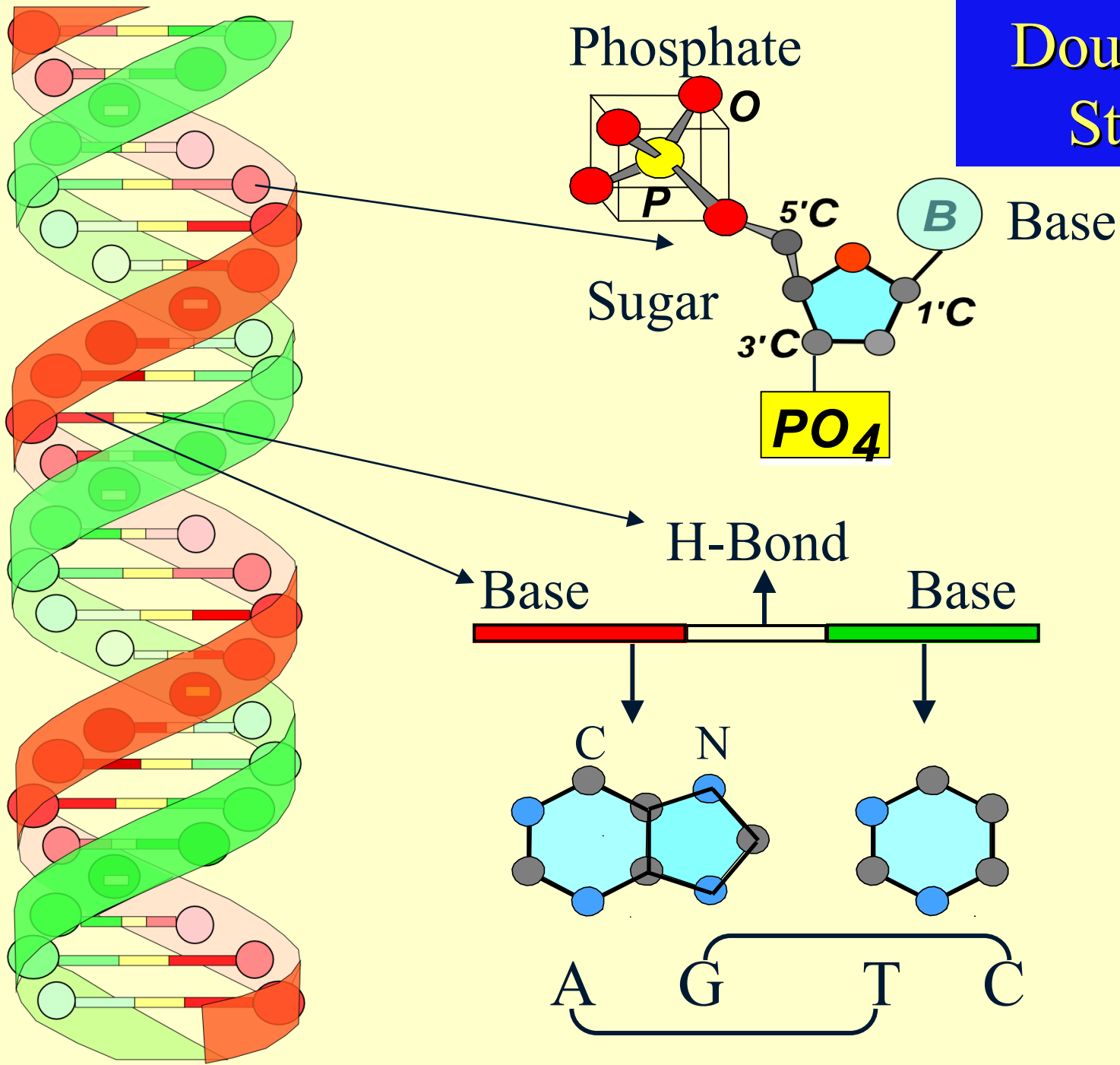
# Crick



Die Entschlüsselung der DNA-Struktur  
1953 gilt als eine der wohl bedeutendsten biologischen Entdeckungen des 20. Jahrhunderts. Die Lösung gelang dem Forscherpaar James Watson (rechts) und Francis Crick (links).

« A decisive breakthrough in human thought is not necessarily the work of an individual genius but only of a pack of bright research workers following a good, well-laid trail. » J.D. Bernal

# Double Helix Structure



# DNA Primary Conformations

## A-DNA

## B-DNA

## Z-DNA

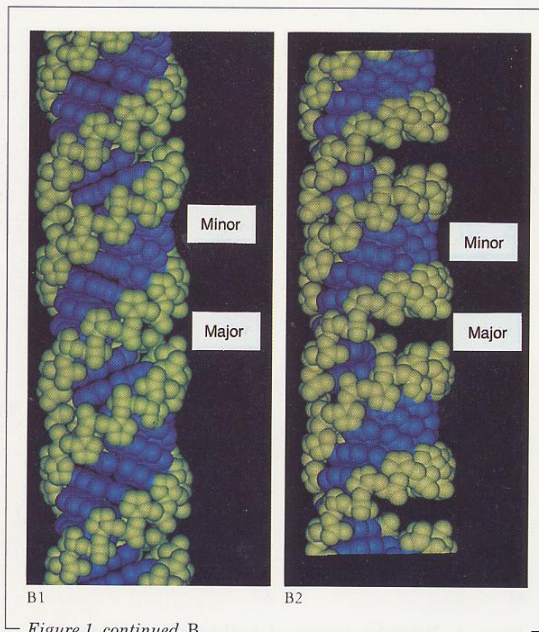


Figure 1, continued B.

A-DNA: In B1, the molecule is vertical, while in B2 it is tilted back. The major groove is very narrow and deep while the minor groove is broad and flat. The entrance of the major groove is quite narrow.

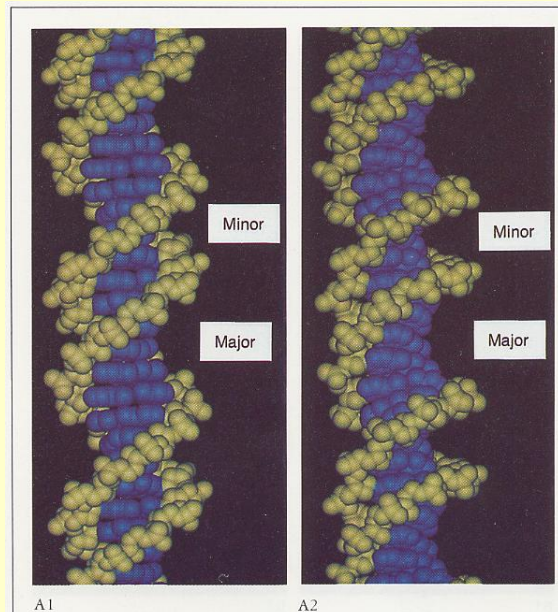


FIGURE 1. Molecular structure of the three principal forms of the DNA double helix. A space-filling model is shown in which the base pairs are colored blue and the sugar phosphate backbone is yellow. The major and minor grooves are labeled. For each model, two views are shown: one in which the model is perpendicular to the line of sight and the second in which the molecular model is tilted slightly more than 30° so that the viewer can see into the grooves in the molecule.

A. B-DNA: In A1 the molecule is vertical, and in A2 it is tipped back. Note that both grooves are accessible.

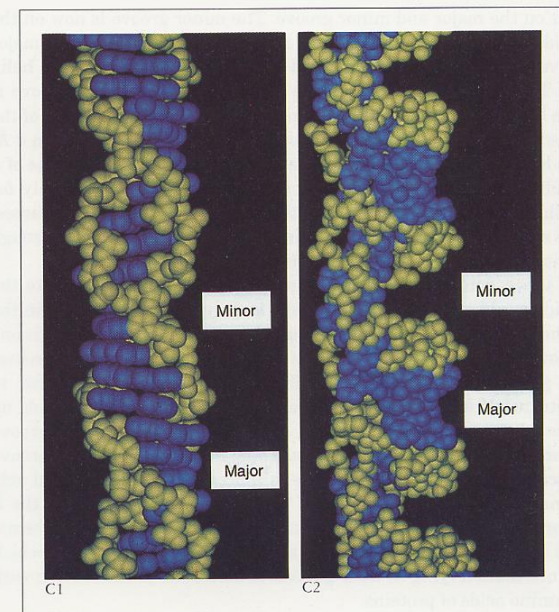


Figure 1, continued C.

Left-handed Z-DNA: The major groove is not a groove but is rather a convex surface on the outer portion of the molecule. The minor groove is rather narrow and deep, as can be seen when the molecule is tilted in C2.

In A-DNA, the helical axis no longer penetrates the base pair but rather is found in the major groove. Thus, the A-type double helix is organized somewhat as a ribbon wrapped around a central core. There is an empty cylindrical region approximately 2 Å in diameter that goes down through the center axis, and the A helix is wrapped around it. Displacement of the DNA away from the helical axis has a profound

and Crick, it was speculated that this major groove could serve as a site for interacting with the  $\alpha$ -helical motif of proteins, since the  $\alpha$ -helix itself has a diameter that could be comfortably accommodated by the major groove. The minor groove was somewhat narrower and it was less clear what its role would be in protein-nucleic acid interactions.

# Nobel 62



Wilkins  
DNA

Perutz  
Hemoglobin

Crick  
DNA

Steinbeck  
Literature

Watson  
DNA

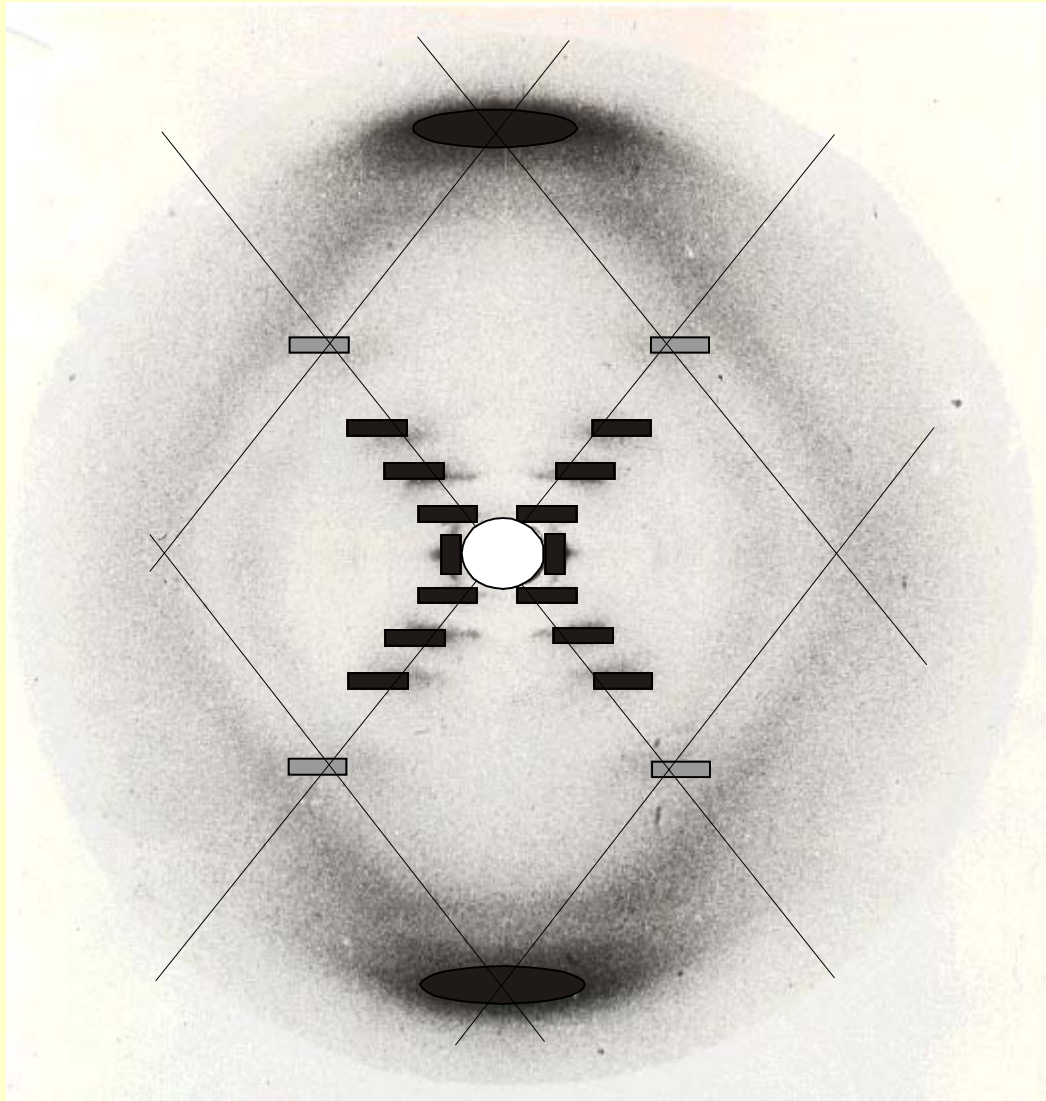
Kendrew  
Myoglobin



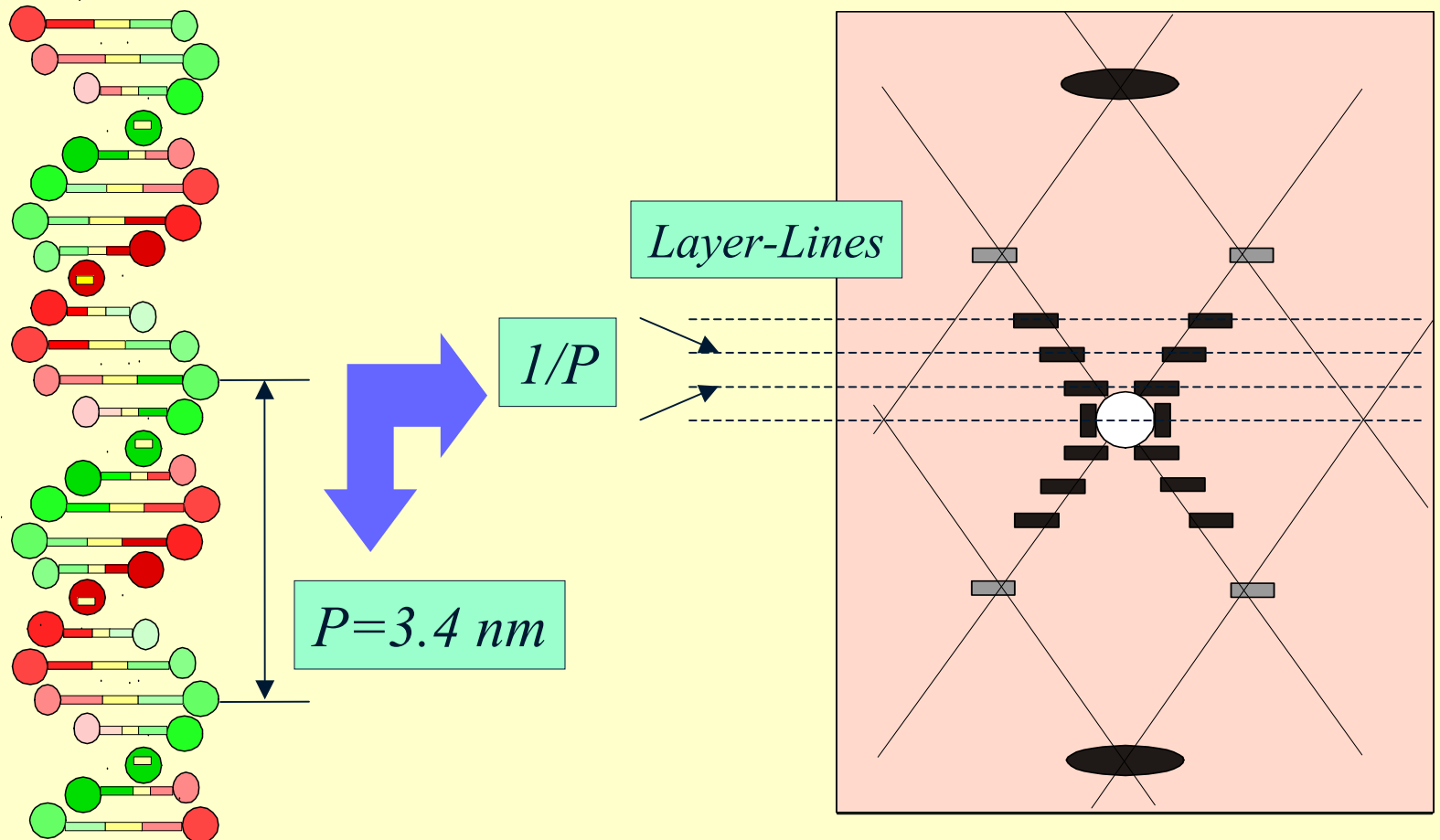
# **B-DNA Diffraction Pattern**

**Four features of Rosalind Franklin's diffraction pattern of B-DNA reveal the complete geometrical structure of the backbone of the double helix.**

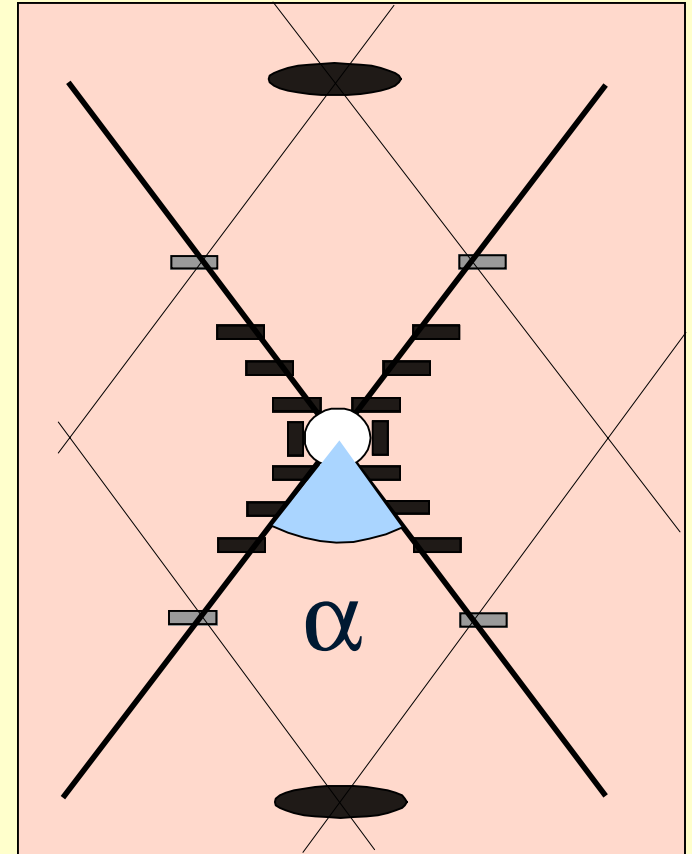
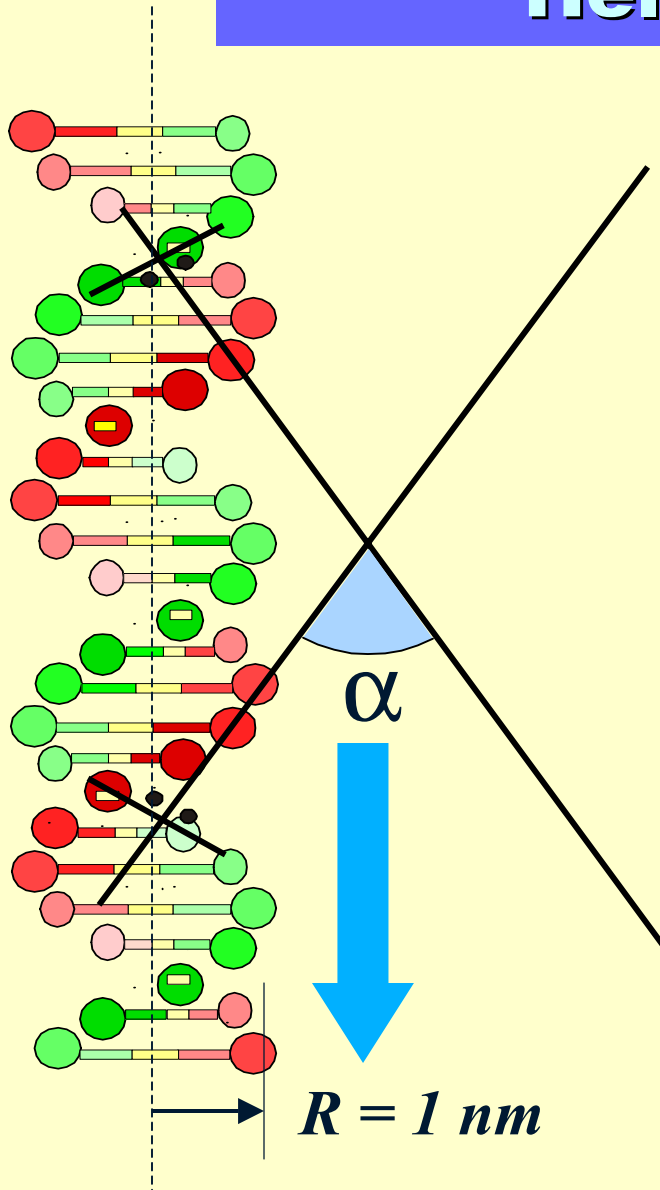
# Schematic representation



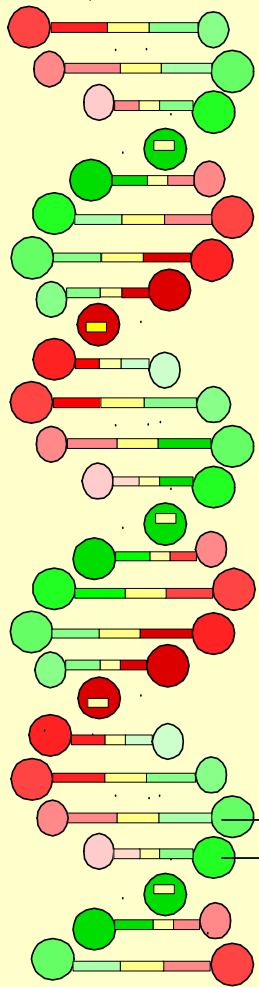
# 1. Layer-Lines : Helix pitch P



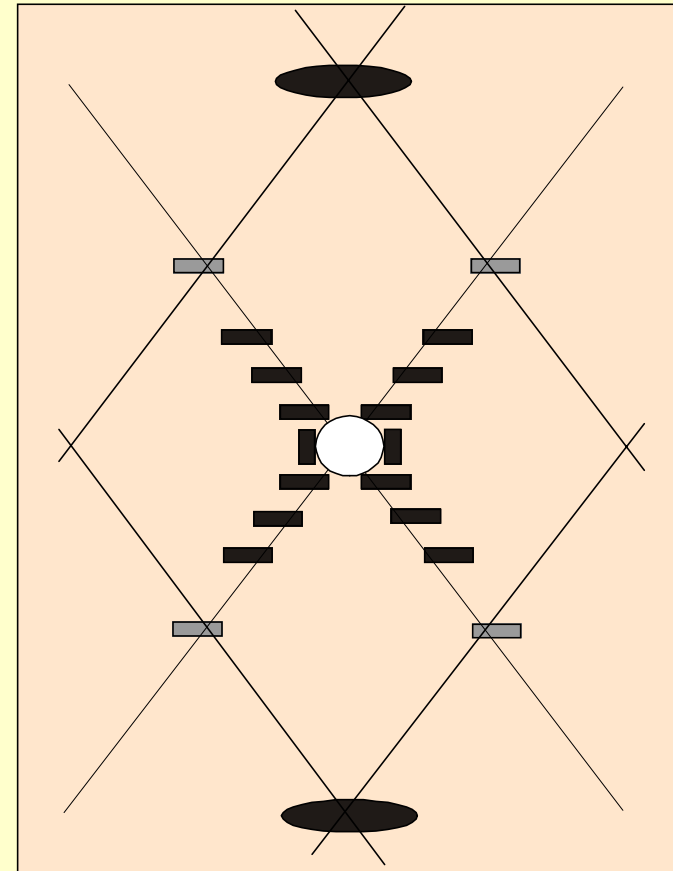
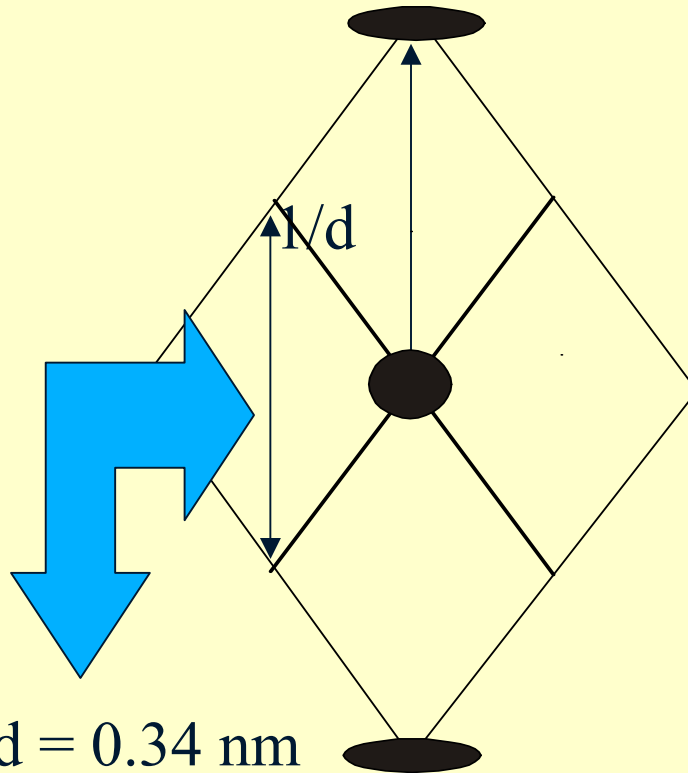
## 2. Saint Andrew Cross : Helix radius



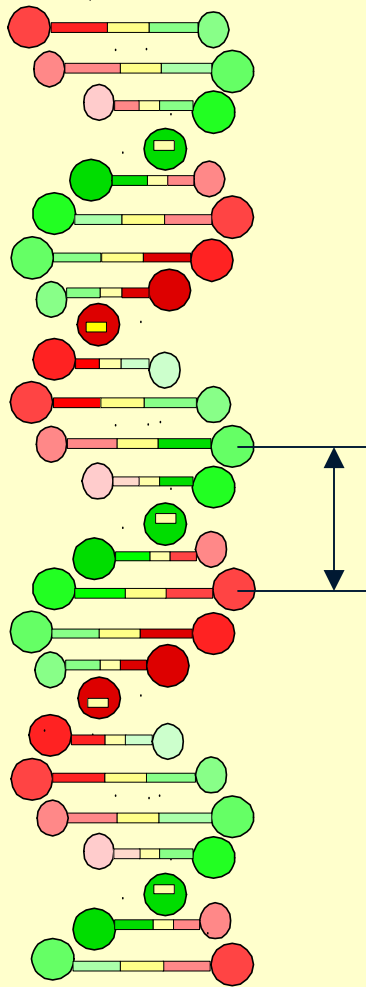
### 3. Diamond pattern : nucleotide repeat d



$d = 0.34 \text{ nm}$



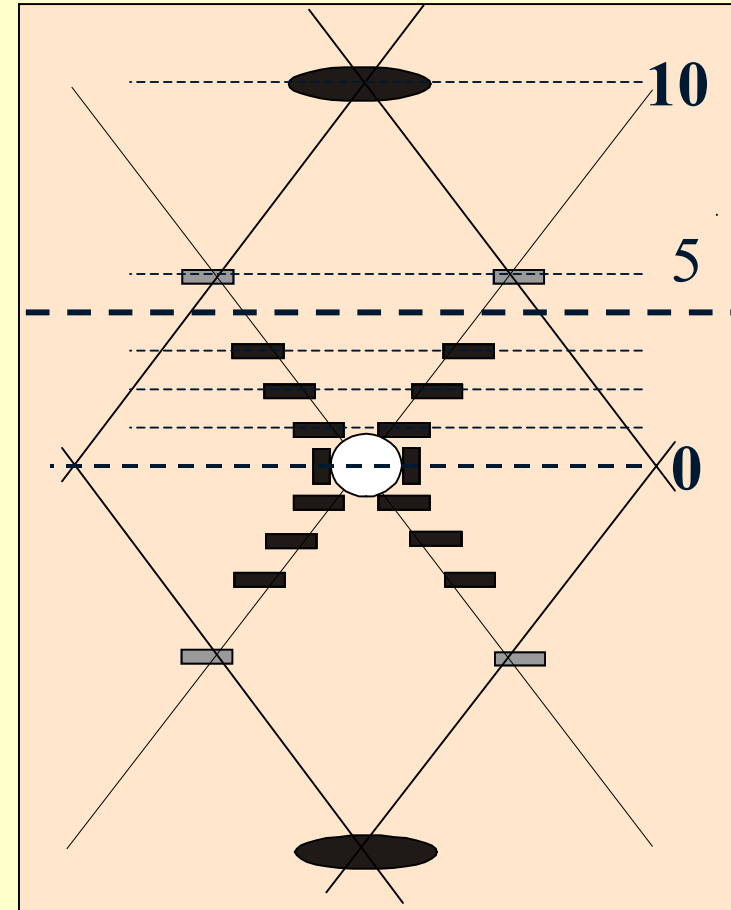
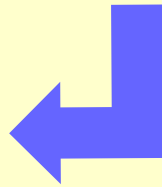
# 4. Missing 4th Layer Line : unequal shift (C2 symmetry)



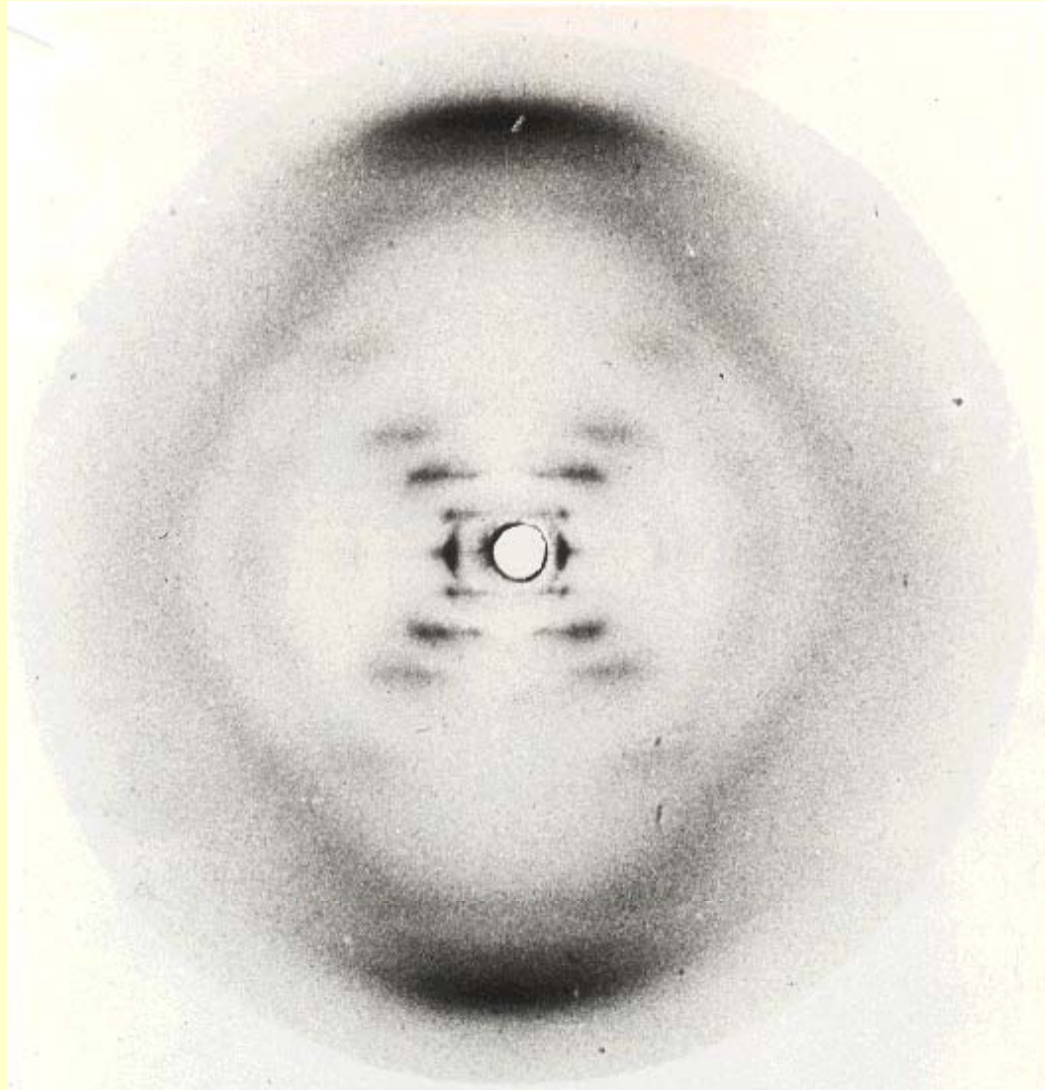
Missing 4th Layer Line

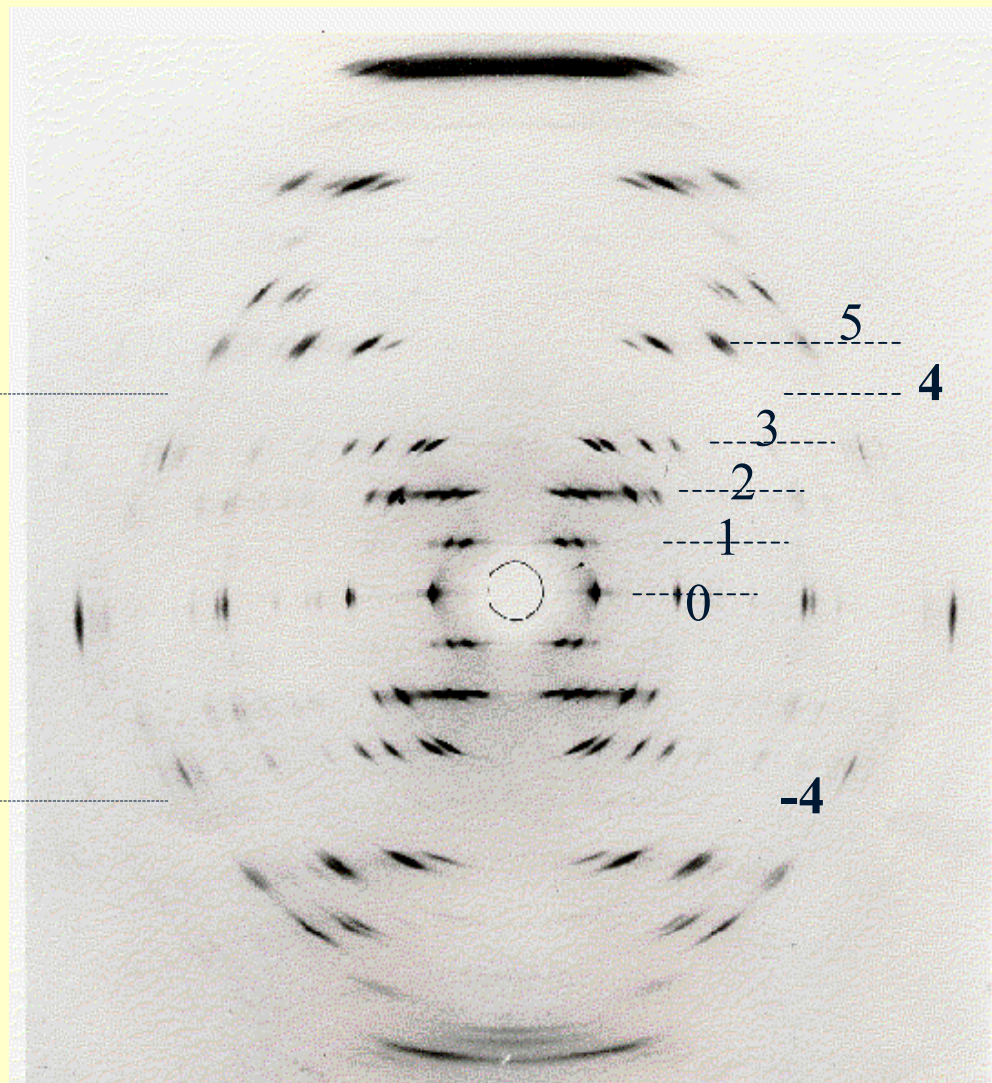
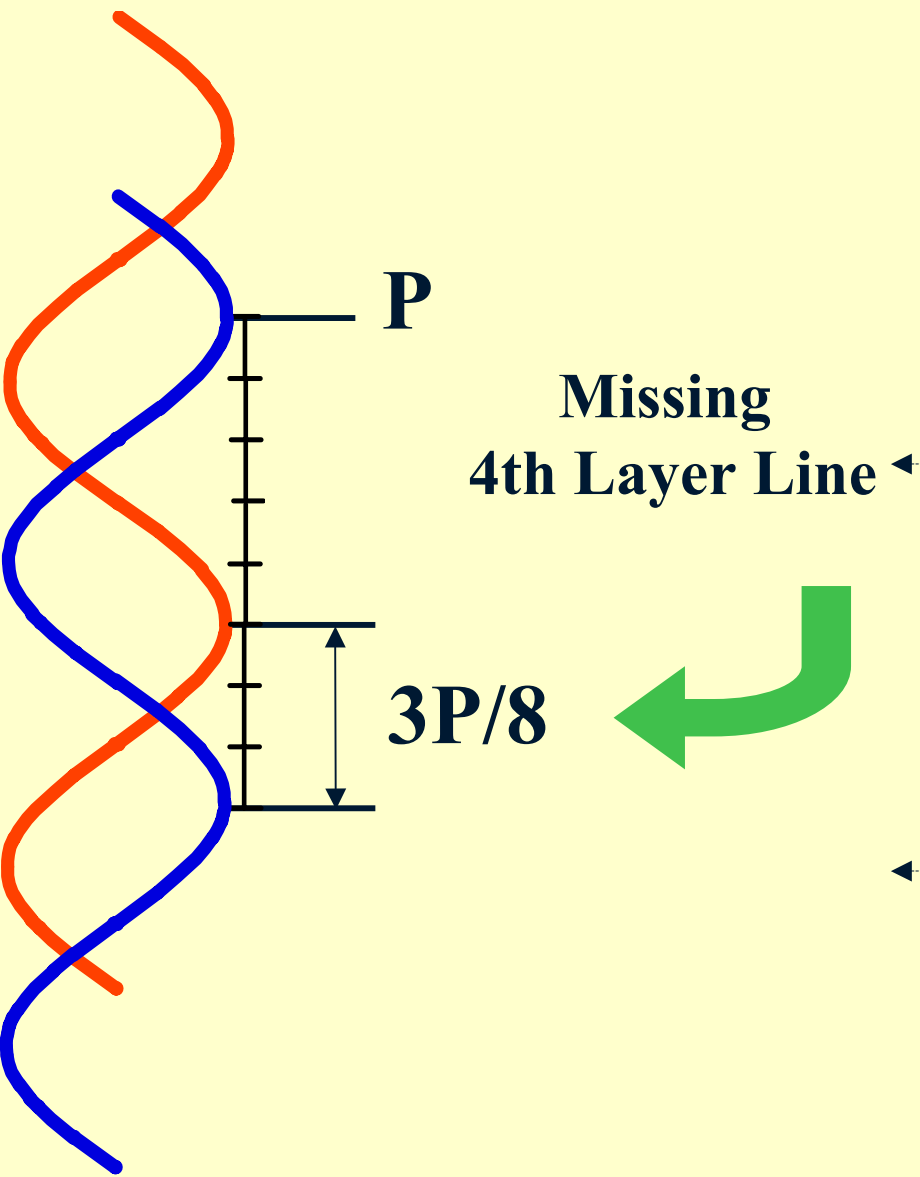
4

$3P/8$



# Rosalind Franklin, 1952



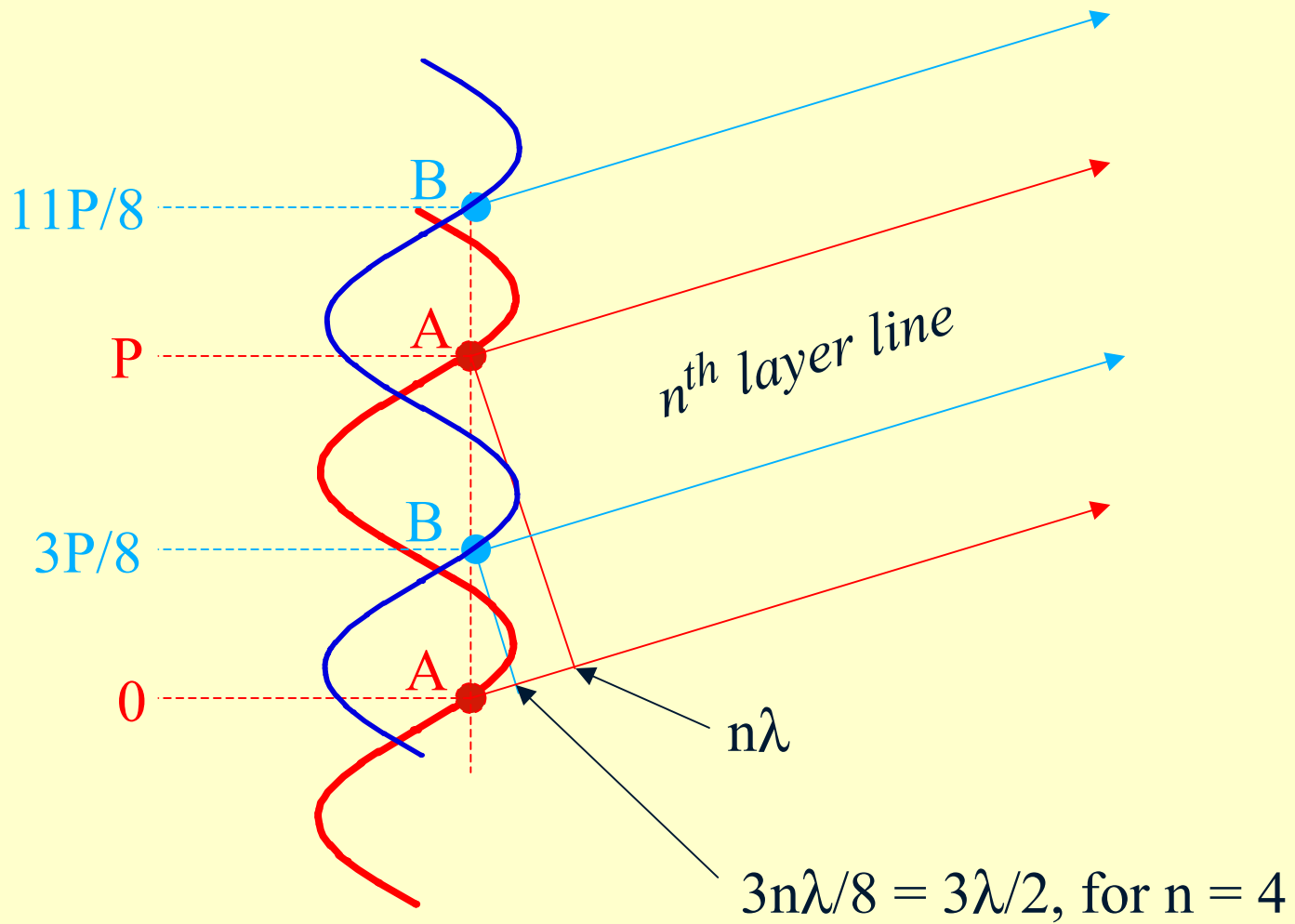


(b)

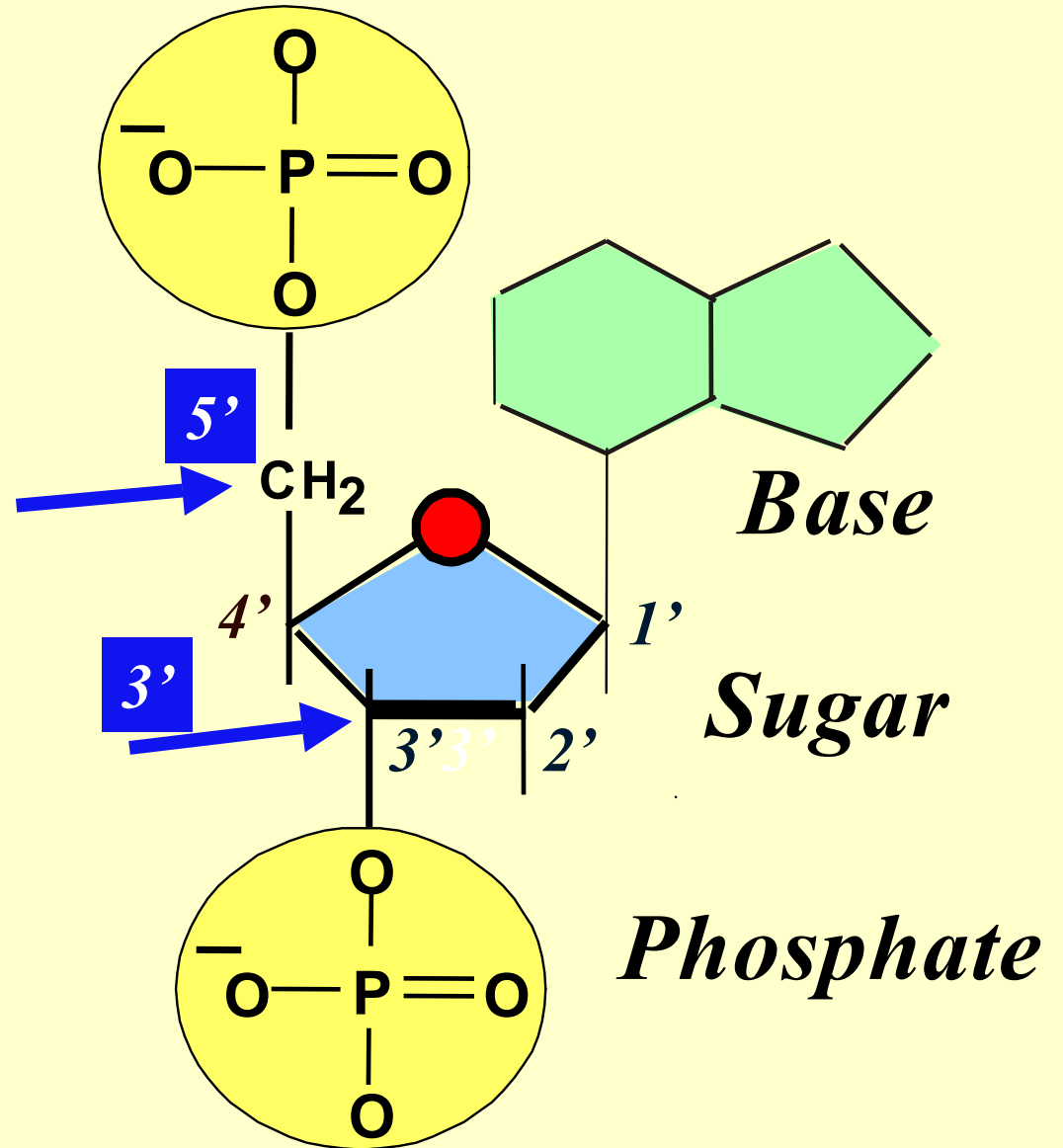
**Wilkins B-DNA Pattern**

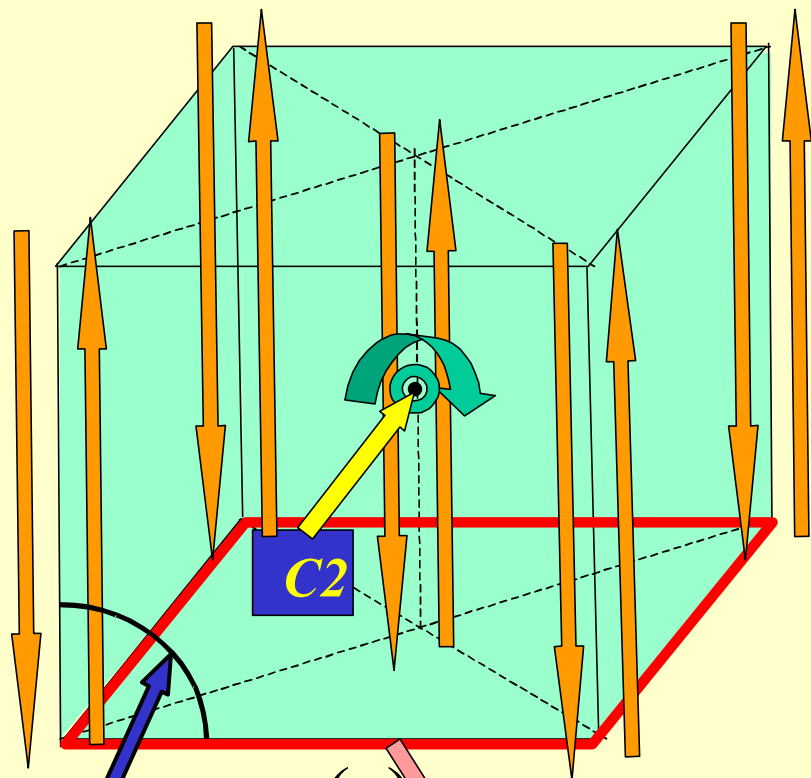
(a)





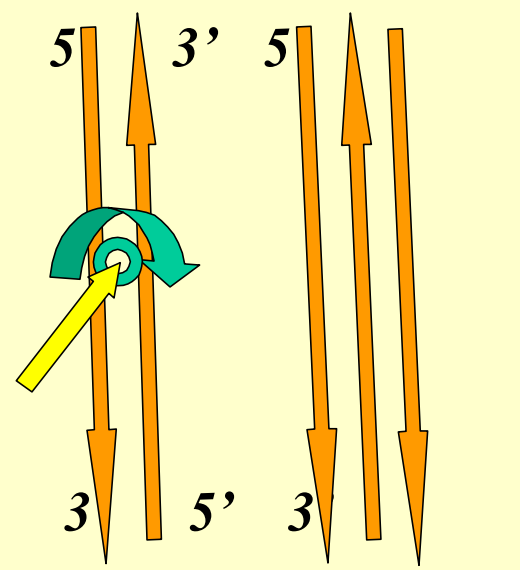
**3'-5' sugar-phosphate connection**





97°

(a)



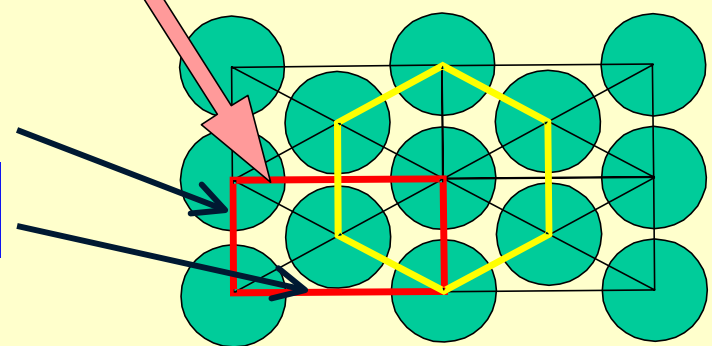
*C2 Dyad*

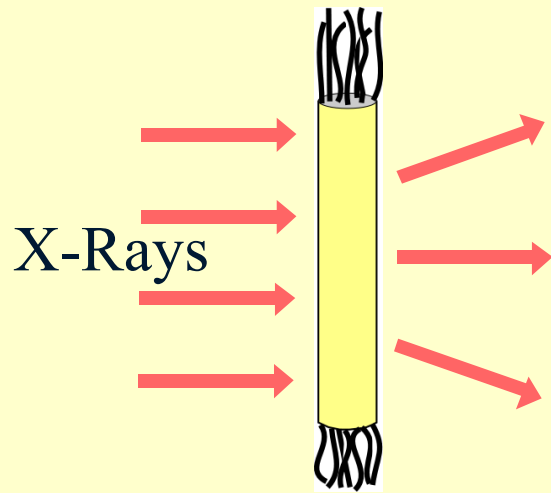
*No Dyad*

(b)

(c)

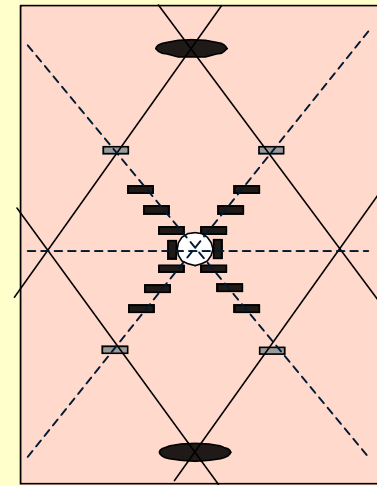
a = 2.2 nm  
 b = 4.0 nm  
 c = 2.8 nm





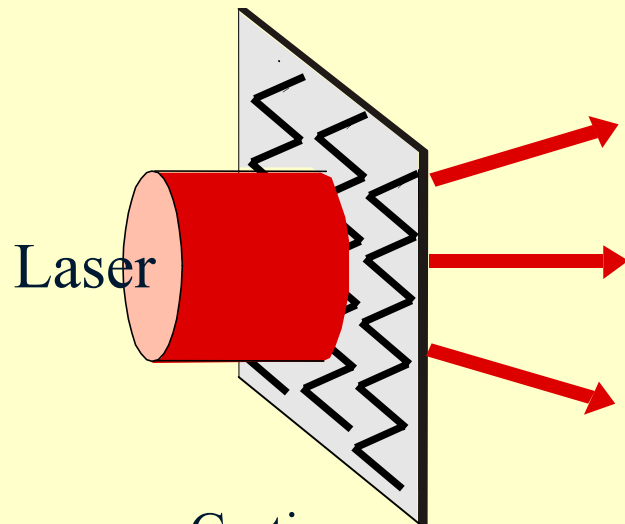
DNA Fiber

Scattered X-rays



Diffraction Pattern

## Optical simulation :



Grating

Scattered light

Diffraction Pattern

